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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN, THE NATIONAL IRONFOUNDING EMPLOYERS' FEDERATION, THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

Institute of British Foundrymen.

JUNE 20-23.

Institute of British Foundrymen:—Annual conference in Cardiff.

Failures.—I.

In a recent interesting Paper to the Institution of Mechanical Engineers, Mr. Schuster dealt with the mechanical breakdown of prime movers and boiler plant. By association with a prominent inspecting body the author has access to much information relating to failures and breakdowns, and he states that metallurgy is a most valuable adjunct in such inquiries and is often indispensable.

The whole Paper is one that foundry metallurgists would be well advised to read.

In dealing with the weakness caused by segregation or blow-holes, he points out that the extent to which a defect weakens material depends entirely on the position of the defect and the form of the stress involved. Where it is at a sudden change of section or point of localised stress it may be disastrous. In a purely tensile member a defect at the centre may be of little moment, as may also be the case when it is located at the centre of a member mainly stressed by bending and twisting. Under other conditions it may be vital.

In a breakdown the origin of the fracture may often be ascertained by finding where a gradually creeping crack began, or where independent cracks unite. Much of the Paper naturally deals with wrought materials.

The fact that castings may stand up satisfactorily throughout a whole lifetime of service and yet contain large defects is a foundry commonplace, and many founders are subconsciously inclined to regard microscopic examination, for example, as of little importance when such conditions can exist. The reason is, of course, that the defect is taken care of, so to speak, by the large factor of safety which engineers still use in design. If, as we believe, the future of cast iron depends on our ability to reduce sections without loss of strength, or, indeed, with a positive increase in strength, then we must learn to make the perfect casting. The breakdown of material under fatigue, and particularly the astonishing cases which have come to light in recent years under the combined effects of corrosion and fatigue, have demonstrated that cases exist in which ordinary factors of safety have no power to safeguard the part concerned.

Time Studies.

For the first time in history there is to be presented to a Congress of the Institute of British Foundrymen a Paper on "Time Studies." It should not be imagined, however, that because there is such a paucity of literature on the subject the parameters of the subject are unknown. Many modern foundries like Harpers, Qualcast, Russells and the Midland Electric Manufacturing Company are familiar with every phase of time studies and actually some of the earliest tests were carried out under Government supervision at the Derwent Foundry of Qualcast before they occupied their present premises. Time study is a laboratory job and requires handling with all the care and perception which one must *force majeure* associate with laboratory practice. In the hands of humane and skilled interpreters analyses resulted from systematic time studies are capable of doing an infinite amount of good, but in the hands of quacks disaster can be expected. We have not yet perused the Paper in question and our remarks must be taken as generalisations. We sincerely hope that the Paper will reveal the benefits and disadvantages which British practice has shown to be inseparable from its institution in any works. Over Whitsuntide we have been making another time study—of the Cardiff Conference programme. After its perusal one cannot but fail to admire the ingenuity and resourcefulness which the local organisers have put into its drawing up. They certainly have done their best, and an excellent best at that, to cater for the catholic tastes of the members of the foundry industry. In congratulating them, we would remind our readers that, viewed from no matter what angle, a visit to Cardiff in a fortnight's time will be well worth while.

XUM

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

The Value of Nickel in Cast Iron.

To the Editor of The Foundry Trade Journal.

Sir,—In your issue dated June 1, I am reported as saying that "*I did not consider the addition of nickel was of much value in the ordinary foundry, whatever may be its use in certain castings for peculiar purposes.*"

My remark as worded above is liable to misconstruction. Nickel is valuable where it cannot be done without and, obviously, that brings into consideration not only the type of castings made in any one foundry, but the knowledge and facilities existing there.

On the other hand, nickel possesses properties of which use may be made probably only by a scientific foundry. At these works we put a proportion of nickel into a peculiar and important crucible-melted cast iron used for single-cast piston rings (where each ring is a separate casting). We used this nickel for a reason which, as far as I know, is not public property nor, perhaps, of interest to anyone else. However that may be, the rings possess properties and structure which obtain favourable comment from engineers and metallurgists—*and* they contain nickel.

Yours faithfully,
H. J. Young
(Hepworth & Grandage, Limited,
Bradford).

June 2, 1933.

Catalogue Received.

Alloy Steel Castings.—We have received from High Speed Steel Alloys, Limited, Ditton Road, Widnes, a 4-page reprint from a technical journal of a Paper carrying the above title by Mr. W. T. Rowden. It contains much useful information of a really practical character. We must, however, protest against the habit of reproducing micrographs carrying (in this case) a 50 per cent. reduction. If such a picture is too big to be conveniently reproduced then a representative area should be chosen. The reprint would have been improved if a few cross-column headings had been used.

Publication Received.

City and Port of Hull.—This excellently-produced handbook carries a dual message. It stresses in three languages the advantages that Hull possesses as a centre for the creation of new industries and its cheapness as a port for the despatch or receipt of goods. One thing of which the City can boast is that it conducts its own telephone service more economically than the Post Office. From the foundry point of view, it possesses an establishment, the National Radiator Company, which must be ranked amongst the largest consumers of pig-iron in the country. However, it is not our duty to pick out all the "high lights" from this brochure, but we feel we can thoroughly recommend its perusal to our readers, to whom no doubt it will be sent gratis on application to the Director of the Development Committee, at the Guildhall, Hull.

The Open-Hearth Process for Steel-Castings Production.—In the course of the Paper carrying the above title, by W. H. Thompson, published in our issue of May 18, the carbon content of the steel for microphotograph Fig. 1, should read 0.14 per cent. and not 0.44 per cent., while in Table I slag analyses sulphur (as SO_3) should read 0.25 per cent. not 6.25 per cent.

To Present French Exchange Paper.

As announced elsewhere in this issue, Mr. V. Bernard is to present, on behalf of the Association Technique de Fonderie, a Paper on "Time Studies in Foundry Practice" to the Cardiff Conference. Mr. Bernard, when 17 years old, joined the laboratory staff of the De Dion-Bouton concern at Puteaux (Seine) as an apprentice chemist, where he successively occupied the positions of analyst, chief chemist in charge of the chemical laboratories and testing house, manager—supervising the chemical laboratory, heat-treatment department—and the technical manager of the foundry and galvanising shops.

Mr. V. Bernard.

Leaving this firm in 1919, he joined the Paris firm "Meccano," manufacturers of twist drills, where he started up a laboratory and controlled the heat-treatment department. In 1921 he assumed his present position of technical manager of the Usines de Rosières in the Cher department.

Slippery Floors.—There are as many kinds of slipping problems associated with floors as there are types of floor. In the case of wood floors a simple method of treatment is to cover the dangerous area with glue and then to pile on a thick coating of sand. When the glue has set the surplus sand can be brushed off. The non-slip effect is good and lasts a considerable time. More expensive but more permanent effects can be obtained by the use of one of the many non-slip flooring materials on the market. They are usually made of special metal combined with abrasive material and can be obtained in tiles or small or large sheets. Rubber is also used. Ordinary metal floors which become slippery owing to the regular and unavoidable accumulation of a coating of oil and grease can be made safer if covered two or three times a week with sand. The sand should not be allowed to accumulate for an indefinite length of time, but should be scraped off once a week. This method may seem cumbersome, but those who have tried it say that it provides good non-slip properties, and that the trouble involved is infinitely better than the previous danger of falls. For concrete floors which become slippery with prolonged wear, treatment with dilute hydrochloric acid is recommended.

Random Shots.

"There'll be a blow-hole somewhere!"

How it all happened was like this: I had been a volunteer on the stand of the Technical Committee of the I.B.F. every day during the recent Foundry Exhibition, from 8 a.m. till 10 p.m., with no time off except to entertain intending applicants for membership to lunches and dinners. Everybody who is anybody and wears a top hat was there, and I had little leisure. During a lull, I fell into a slumber. There I met, again, many friends, all of whom had either bought a new foundry or had been made chief of their respective establishments since I had last seen them Trade was, during the period under review, booming, and my friends decided that nothing at the Exhibition should go unbought by them. We commenced at Stand A1 and finished at 1,001. Everybody was happy.

* * *

Suddenly, a member of the party said: "I thought so. There's a blow-hole in the casting!" Jumping round, I saw the speaker feverishly going through his pockets. Asked the trouble, he said he had not brought his cheque-book. I questioned him what that had to do with a blow-hole in a casting. "If you do not understand 'a blow-hole in a casting,' you are dense," he replied, with a metaphorical smile. "Come round the show with me and learn."

Once again we did the round. At each stall he ordered the most costly apparatus they had for sale. Like clockwork, he was asked by the blue-eyed salesman for credit references, and replied he could give none. The sole comment of each disillusioned salesman in turn was: "I thought there was a blow-hole somewhere!" Arriving at Stand 1,001, I told my companion I now knew what he meant by "There's a blow-hole in the casting." He said: "Oh! Then tell me." I replied: "It means there's a hole in your banking account." Said he: "Guess again." "Well then," said I, "it means there's a fly in the ointment." He answered: "Wake up, and ask your pals." Which I now do. For the best reply my friend offers all he once possessed.

* * *

"What's 'a blow-hole in the casting'?"
Is a question everlasting.
It can't be taken out;
(It sounds it were the gout!)
Perchance it's like a fly
That once fell in your ointment!
It's something you cannot buy,
And it means a disappointment.
So please give me your solution
In language without pollution.
It has naught to do with founding,
Or you I should'nt be sounding.

* * *

Institute Notes.

The coming Conference in Cardiff will be the cutest congregation the Council ever convened.

The Welsh Branch has promised there shall be no druidical sacrifices during the gathering. Members may, therefore, take their daughters, plus-fours and calves with them.

The Hon. Welsh Secretary is, befittingly, a Scotsman. Those who speak only English had better include a dictionary in three languages in their luggage. A few English sayings, such as "What's yours?" are, however, understood by the better educated natives.

The Secretary of the Institute will be on duty at least twenty-four hours each day, and will take charge of all pets and pests; answer all questions, no matter how reasonable; and in every other way make himself generally useful. Incidentally, he will bail out all those who find themselves in the Docks, providing they are not in arrear with their subscription. The Secretary speaks Welsh fluently, which will be a great help to many members.

Marksman.

XUM

The Influence of Phosphorus on the Properties of Hardened and Tempered Cast Iron.*

By J. E. Hurst.

Hardened and tempered cast irons are now being used extensively in many applications in general engineering. For this reason it is necessary that the properties of cast irons in this condition should be more fully and generally understood. In continuance of the work already done,† this investigation has been devoted to a study of the influence of phosphorus on the properties of an oil-hardened and tempered chromium alloy cast iron.

Materials and Preparation of Samples.

Following upon the practice established in previous investigations, the specimens used have been prepared from centrifugally-cast drums. All the heat-treatment experiments and tests have been carried out on annular-ring-form specimens exactly as described previously.†

The centrifugally-cast drums from which the test-pieces were machined were 4.4 in. in outside dia., 3.85 in. in inside dia. by 8 in. long, and equipped with a chucking flange at one end. The ring-form test-pieces were machined from the central portion of the radial thickness of the drums.

The castings were prepared from a chromium alloy mixture made up by melting Barrow hematite, Sheepbridge phosphoric foundry pig-iron, and ferro-chromium. The hematite and ferro-chromium were melted in one crucible and the phosphoric iron in another. Varying quantities of the two melts mixed together and cast, provided a series of castings of varying phosphorus contents. The castings were made under the regular and uniform conditions of casting temperature and die temperature normally adopted in the centrifugal-casting process. Seven different castings were prepared; the full analyses of each are given in Table I.

TABLE I.—*Analyses of Specimens.*

Spec. no.	T.C.	C.C.	Gr.	Si.	Mn.	P.	Cr.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1 ..	3.39	0.52	2.87	2.21	1.07	1.56	0.52
2 ..	3.49	0.49	3.00	2.16	1.08	1.30	0.71
3 ..	3.44	0.30	3.14	2.44	1.01	1.06	0.59
4 ..	3.55	0.46	3.09	2.35	1.00	0.63	0.61
5 ..	3.58	0.39	3.19	2.44	0.93	0.58	0.62
6 ..	3.60	0.54	3.06	2.44	1.09	0.43	0.55
7 ..	3.81	0.59	3.22	2.49	1.02	0.035	0.61

In this range of samples the phosphorus varies from 0.035 per cent. to 1.56 per cent. The total carbon contents increase in the lower phosphorus specimens. The combined carbon contents are somewhat irregular, but tend towards a slightly higher level in the lower phosphorus specimens. The silicon and manganese figures are substantially uniform, as are the chromium contents, with the exception of the specimen No. 2.

Experimental and Testing Procedure.—Twelve ring specimens were prepared from each casting, and Brinell readings were taken from the complete set of all rings. The rings were divided into groups, one group being retained for the determination of the properties in the as-cast condition. Other groups were arranged to enable the properties to be measured after:—(*a*) Hardening; (*b*) hardening and tempering at various temperatures; (*c*) stabilising; (*d*) stabilising, hardening and tempering; (*e*) annealing; (*f*) annealing, hardening and tempering. In every case hardening was carried out by raising the specimens to a temperature of 875 deg. ± 5 deg. C. in an electrical resistance furnace, followed by quenching in oil. Subsequent tempering was performed by maintaining the specimens at the desired temperature in a bath of molten salts for a period of 10 to 15 min.

The stabilising treatment used consisted of maintaining the rings at a temperature of 550 deg. ± 5 deg. C. for a period of 20 min. followed by slow cooling in still air. For the annealing treatment the specimens were packed in cast-iron borings and held at a temperature of 900 deg. C. for a period of 50 min. followed by slow cooling in the furnace.

The exact details of the testing procedure adopted have been described previously (*loc. cit.*), and included the determination of the following properties:—(*a*) The Brinell hardness (Firth hardometer, 2-mm. ball, 30-kg. load); (*b*) the *EN* value (modulus of elasticity); (*c*) the permanent set value; (*d*) the stress/deflection curve; (*e*) the tensile strength; and (*f*) the internal stress value.

It has been found possible to include a comparative study of the internal stress value, item (*f*) in the above list. When cutting gaps in test rings of this form it is noticed that the cut ring may show a tendency to open or to close. By cutting the gap in the ring whilst it is held in a clamp, the gap, as cut, can be measured. The difference between this gap measurement and the free gap measurement after the release of the clamp indicates the amount of gap movement. This has been recorded for each of the specimens; a positive gap movement indicates opening and a negative gap movement indicates closing of the gap. This movement of the rings on slitting is due to internal stresses, and the magnitude of this movement may be used as a comparative guide to the change in the internal stress conditions. Since all the test rings are accurately machined and their dimensional differences are of a very small order, it is considered that the recording and comparison of the gap movement in inches is sufficient for the purposes of this investigation.

The complete test results obtained are set out in Tables II to XIV. In the case of the hardened untempered specimens, after stabilising and after annealing no determinations of the mechanical properties beyond the Brinell hardness were made; these hardness results are included in Table XII.

AS-CAST, HARDENED AND TEMPERED.

The whole of these results are included in Tables II to VIII, which include the properties obtained from as-cast, and from hardened and tempered specimens, tempered at successively increasing temperatures. In order to avoid complexity arising from a large number of curves in the diagrammatic representation of some of these properties, selected cases only have been used in the diagrams.

TABLE II.—*Specimens as Cast.*

Spec. no.	Internal stress; gap movement. In.	Permanent set. Per cent.	*EN* value. Lb. per sq. in. × 10^6.	Tensile strength. Tons per sq. in.	Brinell hardness number.
1 ..	+ 0.008	6.29	19.17	17.7	310
2 ..	+ 0.008	6.28	18.31	16.8	295
3 ..	+ 0.006	6.50	18.40	19.32	290
4 ..	+ 0.010	7.64	18.0	18.48	268
5 ..	+ 0.018	6.23	17.83	20.16	270
6 ..	+ 0.014	9.16	17.36	21.06	259
7 ..	+ 0.010	13.28	16.75	21.90	244

TABLE III.—*Specimens Quenched in Oil from 875 deg. C.*

Spec. no.	Internal stress; gap movement. In.	Permanent set. Per cent.	*EN* value. Lb. per sq. in. × 10^6.	Tensile strength. Tons per sq. in.	Brinell hardness number.
1 ..	− 0.008	6.56	17.3	18.69	580
2 ..	—	—	—	—	572
3 ..	− 0.010	6.43	16.56	14.0	494
4 ..	− 0.006	6.04	15.84	15.22	522
5 ..	− 0.006	—	16.46	13.76	556
6 ..	− 0.016	—	15.04	14.0	560
7 ..	− 0.024	—	12.91	14.0	534

TABLE IV.—*Specimens Quenched in Oil from 875 deg. C. and Tempered at 250 deg. C.*

Spec. no.	Internal stress; gap movement. In.	Permanent set. Per cent.	*EN* value. Lb. per sq. in. × 10^6.	Tensile strength. Tons per sq. in.	Brinell hardness number.
1 ..	− 0.032	2.15	18.3	16.36	551
2 ..	− 0.012	2.05	16.3	17.82	502
3 ..	− 0.016	2.80	16.76	17.99	412
4 ..	− 0.008	3.17	16.13	23.13	518
5 ..	− 0.002	2.14	15.47	20.11	474
6 ..	− 0.002	3.5	16.35	22.87	518
7 ..	− 0.038	5.84	13.3	23.60	474

TABLE V.—*Specimens Quenched in Oil from 875 deg. C. and Tempered at 300 deg. C.*

Spec. no.	Internal stress; gap movement. In.	Permanent set. Per cent.	*EN* value. Lb. per sq. in. × 10^6.	Tensile strength. Tons per sq. in.	Brinell hardness number.
1 ..	− 0.004	3.14	17.78	21.07	551
2 ..	− 0.010	3.17	16.58	17.6	518
3 ..	− 0.010	3.84	17.07	20.94	488
4 ..	− 0.002	3.07	16.15	19.6	460
5 ..	− 0.004	3.82	16.53	21.91	435
6 ..	− 0.002	3.20	15.65	19.06	518
7 ..	− 0.016	5.63	12.60	25.66	435

TABLE VI.—*Specimens Quenched in Oil from 875 deg. C. and Tempered at 350 deg. C.*

Spec. no.	Internal stress; gap movement. In.	Permanent set. Per cent.	*EN* value. Lb. per sq. in. × 10^6.	Tensile strength. Tons per sq. in.	Brinell hardness number.
1 ..	− 0.002	2.91	18.12	18.15	502
2 ..	− 0.022	3.20	16.96	17.71	488
3 ..	− 0.020	1.50	16.53	20.64	488
4 ..	− 0.010	3.17	16.25	20.16	488
5 ..	− 0.010	3.91	16.59	21.04	460
6 ..	− 0.012	3.04	16.19	25.74	488
7 ..	− 0.012	6.00	13.50	26.8	460

TABLE VII.—*Specimens Quenched in Oil from 875 deg. C. and Tempered at 450 deg. C.*

Spec. no.	Internal stress; gap movement. In.	Permanent set. Per cent.	*EN* value. Lb. per sq. in. × 10^6.	Tensile strength. Tons per sq. in.	Brinell hardness number.
1 ..	− 0.020	3.22	18.2	19.7	448
2 ..	− 0.012	3.43	16.91	15.94	448
3 ..	− 0.006	3.00	17.71	19.92	352
4 ..	− 0.024	2.96	16.64	18.11	412
5 ..	− 0.018	3.71	16.65	19.35	435
6 ..	− 0.014	3.63	16.07	20.39	423
7 ..	− 0.004	6.05	13.52	26.22	380

Brinell Hardness.

The hardness in the as-cast condition shows a steady increase with increasing phosphorus content. This is as would be expected, and is clearly shown in the lower curve of Fig. 1. In the

* A Paper read before the Spring Meeting of the Iron and Steel Institute.

† HURST, "Proceedings of the Institute of British Foundrymen," 1930-31, Vol. 24, p. 373. Papers read before the Institute of British Foundrymen; FOUNDRY TRADE JOURNAL, 1931, Vol. 45, p. 348; 1932, Vol. 47, p. 37.

quenched condition the hardness values are raised to within the range of 500 to 580. In this condition the effect of increasing phosphorus appears to cause higher hardness values, with the exception of the curious behaviour of the two samples with intermediate phosphorus contents of 0.63

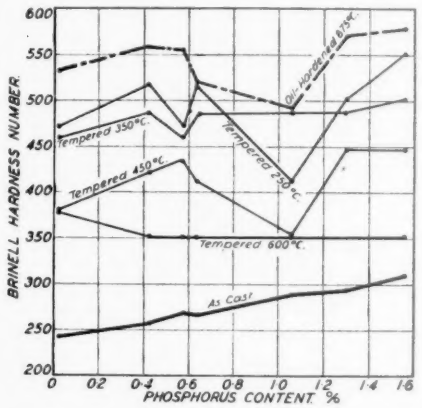

Fig. 1.—Brinell Hardness Numbers, as Cast, Hardened, and Tempered.

and 1.06 per cent., which do not attain the high level of hardness and consequently produce the curious inflexion in the hardness curve, Fig. 1.

In the tempered conditions the hardness is lowered with increasing tempering temperature, and with a tempering temperature of 600 deg. C. values of 350 to 375 are obtained. The pecu-

Table VIII.—*Specimens Quenched in Oil from 875 deg. C. and Tempered at 600 deg. C.*

Spec. no.	Internal stress; gap movement. In.	Permanent set. Per cent.	*EN* value. Lb. per sq. in. × 10^6.	Tensile strength. Tons per sq. in.	Brinell hardness number.
1 ..	+ 0.002	3.94	18.63	17.44	352
2 ..	+ 0.008	4.61	18.22	17.6	352
3 ..	+ 0.002	3.56	17.58	19.36	352
4 ..	+ 0.008	3.97	16.64	17.9	352
5 ..	+ 0.006	3.81	16.95	19.77	352
6 ..	+ 0.004	4.16	16.06	21.06	352
7 ..	+ 0.010	7.02	14.11	21.6	378

liar behaviour of the two specimens with intermediate phosphorus contents persists, but not consistently, on tempering up to 450 deg. C. In all cases the high-phosphorus specimens maintain uniformly a higher level of hardness than the low-phosphorus ones, in spite of the initial higher combined carbon contents of the latter.

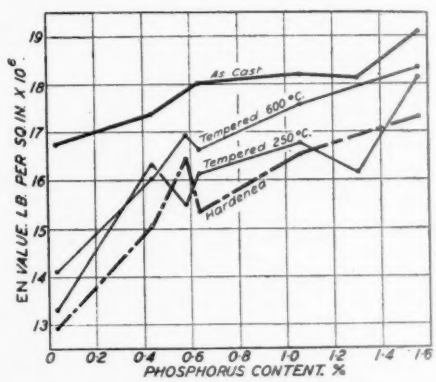

Fig. 2.—*EN* Values, as Cast, Hardened, and Tempered.

At a tempering temperature of 600 deg. C. all the irregularities are smoothed out and a practically uniform hardness for all phosphorus contents is attained.

It is difficult to ascertain from these results whether the curious behaviour of the intermediate-phosphorus specimens is an intrinsic effect of the phosphorus, and the matter must be left for further investigation.

EN Value.

In the as-cast condition this value shows a marked and steady increase with increasing phosphorus contents. In the hardened and hardened and tempered conditions, an increase in the phosphorus is accompanied by an increase in the *EN* value, although the effect of these treatments in each case is to lower the general level of this value. Tempering at the higher temperature of 600 deg. C. is accompanied by a recovery of the *EN* value in all specimens in the direction of the values of the as-cast condition. The fall in the *EN* value due to hardening is greatest in the lowest-phosphorus specimens, and an increase in the phosphorus appears to minimise the reduction of this value due to this cause (see Fig. 2).

Tensile Strength.

The effect of increasing phosphorus in the as-cast condition is to cause a rapid and steady decline in the tensile strength. These results are shown in Fig. 3. As discovered in previous investigations (*loc. cit.*), the hardening operation is accompanied by a substantial drop in the strength values, and subsequent tempering operations result in a marked recovery to strength values still higher than those of the original material as cast.

The effect of an increase in the phosphorus on the drop in the tensile strength due to hardening is rather curious. The falling-off is greatest in the low-phosphorus specimens, and diminishes with increasing phosphorus up to 1 per cent.; in fact, up to this phosphorus content the strength value in the hardened condition is approximately constant. No drop in strength is experienced in the hardened specimen containing 1.5 per cent. of phosphorus. Actually, the strength of this specimen in the hardened condition is slightly higher than that of the as-cast specimen. The 1.3 per cent. phosphorus hardened specimen unfortunately failed in handling.

An increase in the phosphorus content likewise appears to affect the magnitude of the recovery and also the increment in strength above the original as-cast value. The magnitude of the recovery in strength and that of the increment, as compared with the as-cast condition, diminish with increasing phosphorus. The highest strength values in the tempered condition are attained by the lower-phosphorus specimens.

In Fig. 4 the strength results have been plotted in relation to the tempering temperature. The strength of the lowest-phosphorus specimen attained a clearly-defined maximum with a tempering temperature of 350 deg. C. With increasing phosphorus contents the maximum becomes less pronounced and less in magnitude and, if anything, shows a tendency to occur at a slightly lower tempering temperature.

Permanent Set.

Fig. 5 shows the effect of increasing phosphorus contents on the permanent set. The results are plotted for the as-cast condition and the conditions of minimum and maximum tempering temperatures. In all cases the magnitude of the permanent set diminishes steadily with increasing phosphorus contents. Hardening and tempering result in a substantial lowering, and tempering at increasing temperatures is accompanied by a tendency for the permanent set to recover in the direction of the as-cast condition. Even with a tempering temperature of 600 deg. C. the permanent set values, particularly in the lower-phosphorus specimens, are substantially lower than those for the as-cast condition.

Internal Stress.

The comparative study of the internal stress conditions from the determinations of the gap movement during slitting is of interest. Some of the values are plotted in relation to increasing phosphorus contents in Fig. 6. All the specimens in the as-cast condition showed positive gap movements, indicating the initial presence of internal stresses. The amounts of gap movement

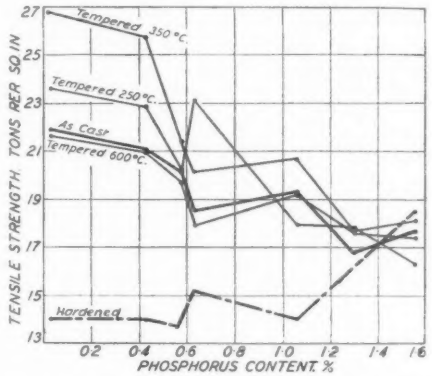

Fig. 3.—Tensile Strength, as Cast, Hardened, and Tempered.

in these specimens varied somewhat irregularly, and no relation between them and the amount of phosphorus present is apparent.

All the specimens in the hardened condition showed a complete reversal of the internal stress conditions and recorded a negative gap movement of substantial magnitude in the lowest-phosphorus specimen. The curve for the gap movement in the hardened specimens is shown in Fig. 6, and appears to show that in this condition the gap movement diminished with increasing phosphorus.

The gap movements in all the tempered specimens varied most irregularly, but in all cases up to and including the tempering temperature of 450 deg. C. the gap movements were negative in sign. With a tempering temperature of 600 deg. C. the gap movements reverted to the positive sign as in the as-cast condition, but were consistently lower in value. This observation would lead one to suspect the existence of a critical tempering temperature at which the internal stress condition as revealed by the gap movement is zero. By re-plotting the gap movements in relation to the tempering temperature, it would appear that the critical temperature for these specimens lies within the range of 500 to 570 deg. C. This observation is one of obvious importance in the practical heat-treatment of cast iron by hardening and tempering.

Stress Deflection Curves.

The stress deflection curves have been determined and drawn for each specimen. The

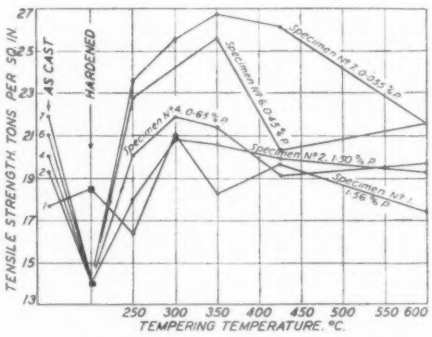
TENSILE STRENGTH TONS PER SQ.IN
TEMPERING TEMPERATURE. °C.
AS CAST
HARDENED
Specimen No 2 0.355 % P
Specimen No 6 0.425 % P
Specimen No 4 0.61 % P
Specimen No 2 1.30 % P
Specimen No 1 1.96 % P

Fig. 4.—Tensile-Strength/Tempering-Temperature Relationship, as Cast, Hardened, and Tempered.

included areas of each curve at the original scale of plotting are assembled in Table IX. In the as-cast condition the areas increase steadily with the decrease in the phosphorus, and with two

exceptions this is maintained in the hardened and tempered condition. With the exception of the 1.56 per cent. phosphorus specimen, hardened and tempered at 250 deg. C., no decrease in the included area of the curves is found in the hardened and tempered conditions. In almost every case there is an increase, and in the low-

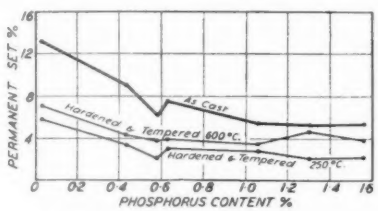

FIG. 5.—PERMANENT SET, AS CAST, HARDENED, AND TEMPERED.

phosphorus specimens this is of a very substantial order.

The maximum increase in area in the high-phosphorus specimens, from 1 per cent. upwards, occurs at a tempering temperature of 300 deg. C. Below this the maxima in specimens Nos. 4 and 7 occur at tempering temperatures of 250 deg. and 450 deg. C., respectively. In specimens Nos. 5 and 6 the maxima occur at a tempering temperature of 350 deg. C. In the as-cast condition the character of the curves changes very distinctly with increasing phosphorus contents. With decreasing phosphorus there is a marked increase in the curvature in the upper ranges of the curves. Hardening and tempering is accompanied by an almost complete elimination of this curvature, even in the lowest-phosphorus specimen, and, whilst there is evidence of a recovery of this curvature with increasing tempering temperature, it is of a comparatively slight order only in the specimens tempered at

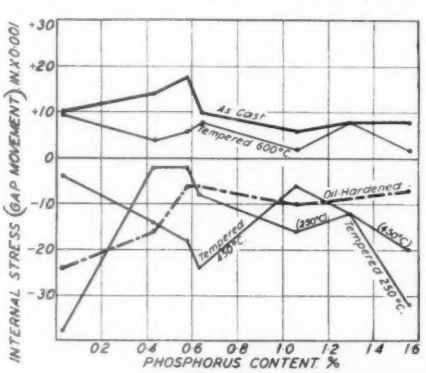

FIG. 6.—GAP MOVEMENT (INTERNAL STRESS), AS CAST, HARDENED, AND TEMPERED.

600 deg. C. This difference in character is clearly shown in Figs. 7 and 8.

If the included areas of the curves are accepted as a comparative measure of the toughness as opposed to brittleness, these results indicate an increase in the toughness with a decrease in the phosphorus content. Hardening and tempering is accompanied by an increase in the toughness as compared with that of the as-cast material, and this increase is of a very substantial order in the lower-phosphorus material. The reduction in curvature of the curves shows that hardening and tempering tends to alter the character of the material by minimising the extent of the plastic deformation. In a measure this is borne out by the reduction in the permanent set values.

THE STABILISED CONDITION.

The test results obtained on the specimens stabilised at 550 deg. C. for 20 min. and also on similar stabilised specimens after hardening and after hardening and tempering at 350 deg. C. are given in Tables X, XI and XII.

Brinell Hardness.

As compared with the as-cast condition, the hardness is, on the whole, very slightly lower, and the stabilising treatment has had very little effect. The specimens after quenching and after quenching and tempering increase in hardness in a manner similar to the as-cast material. There is no noticeable effect on the hardness values attained which can be attributed clearly to the initial stabilising treatment. The 1.5 per cent. phosphorus specimen records an exceptionally high value, and a minimum value is recorded with a phosphorus content of 1.3 per cent. in this instance.

TABLE IX.—*Included Areas of Stress Deflection Curves.*

Specimen no.	1.	2.	3.	4.	5.	6.	7.
	Sq. in.	Sq. in.	Sq. in.	Sq. in.	Sq. in.	Sq. in.	Sq. in.
As cast	4.0	4.0	4.8	4.8	5.9	6.4	7.1
H. and T. at 250 deg. C.	3.6	4.8	4.8	8.6	6.5	8.4	11.2
„ „ 300 „	6.6	5.6	6.5	6.1	7.4	5.2	14.4
„ „ 350 „	4.5	4.6	6.1	6.4	7.5	10.9	14.5
„ „ 450 „	5.1	4.0	5.6	5.3	5.9	7.1	19.6
„ „ 600 „	4.2	4.2	—	5.2	5.8	7.2	11.1
Stabilised	3.7	3.7	4.5	5.7	6.7	13.9	15.75
„ H. and T. at 350 deg. C.	7.0	6.25	7.0	5.9	10.4	10.9	17.4
Annealed	—	—	—	—	—	—	—
„ H. and T. at 250 deg. C.	3.25	4.5	13.5	10.25	6.3	9.6	12.7
„ H. and T. at 350 deg. C.	8.0	7.0	9.4	14.7	18.5	10.5	15.1

EN Value.

With the exception of the specimen containing 1.5 per cent. of phosphorus, stabilising has been accompanied by a reduction in the *EN* values as compared with those of the as-cast material. The magnitude of the reduction is greater in the low-phosphorus specimens. The effect of hardening and tempering the stabilised material is to cause a slight reduction only in the *EN* value, with the one exception of the high-phosphorus specimen. As in the as-cast condition, the *EN* value increases with an increase in the phosphorus content, and in the hardened and tempered condition the values obtained correspond closely with those of the as-cast material in the same condition.

Tensile Strength.

As in the as-cast condition, the tensile strength decreases with an increase in the phosphorus, and the effect of stabilising has been to lower the values as compared with that condition. In the hardened and tempered condition a phenomenally high value was obtained for the low-phosphorus specimen (phosphorus 0.035 per cent., hardened and tempered at 350 deg. C.), but apart from this, values approximately on the same level as those of the as-cast material were obtained.

Permanent Set.

The effect of the stabilising treatment has been to increase the permanent set values above those obtained for the as-cast condition, but the fall in value with an increase in phosphorus still persists. In the hardened and tempered condition the permanent set is lowered to values very similar to those in the as-cast specimen hardened and tempered at 350 deg. C.

Internal Stress.

The internal stress conditions, as indicated by the gap movement, in these stabilised specimens

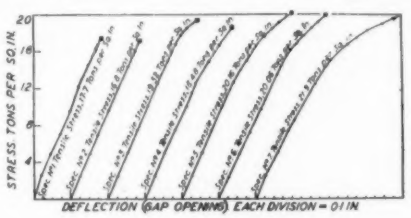

FIG. 7.—STRESS-DEFLECTION CURVES, AS CAST.

are unexpected. With the exception of the maximum-phosphorus specimen, they all show a higher positive gap movement than the as-cast material. As in the latter, hardening and tempering is accompanied by a reversal to a negative gap movement of greater magnitude than that for the corresponding as-cast specimens.

Stress/Deflection Curves.

In the three specimens containing 1 per cent. of phosphorus and upwards, stabilising has resulted in a slight lowering of the included areas of the stress/deflection curves. Below 1 per cent. of phosphorus, all the specimens show an increase in the included area, the increase being of a substantial order in the lowest-phosphorus specimens. Hardening and tempering has again had the effect of increasing this value, most of the specimens showing a substantial increase. The degree of curvature is affected very little by the stabilising treatment, but in the hardened and tempered condition it is very considerably reduced.

THE ANNEALED CONDITION.

The results are recorded in Tables XII, XIII, XIV and XV. As already indicated, the annealing treatment was carried out at 900 deg. C. for a period of 50 min., followed by slow cooling. The specimens were annealed packed in a canister filled with cast-iron borings to prevent oxidation, and after treatment the machine specimens showed a dull metallic surface with no trace of scaling. The surfaces of the specimens Nos. 1 and 2 (1.56 and 1.30 per cent. of phosphorus) lost their smooth machined finish and became roughened to the touch, showing small surface excrescences when examined under a hand lens. The remaining specimens showed no trace of this effect. It is impossible to resist connecting this observation with the high-phosphorus contents of these two specimens, and it may be due to the liquation of the phosphide

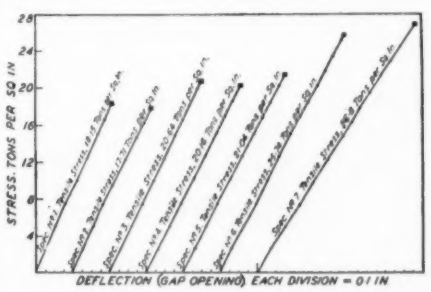

FIG. 8.—STRESS-DEFLECTION CURVES, HARDENED AND TEMPERED AT 350 DEG. C.

constituent within the specimens or the adherence of particles of the borings to the surfaces by reason of the high phosphorus content. In view of this observation, as will be seen from an examination of the test results given in Tables XII to XV, it is remarkable that the tensile

strengths of these two specimens are actually higher than those of the corresponding as-cast specimens.

Brinell Hardness.

Annealing has had the effect of reducing the Brinell hardness as compared with that of the as-cast specimens. The reduction in hardness increases steadily with the rising phosphorus content and is greatest in the specimens with the most phosphorus. In the hardened condition, considerable irregularity was found in the readings on each specimen The minimum and maximum values recorded for each specimen are given in Table XII; the difference between the minimum and maximum values is greatest in the two high-phosphorus specimens. Below 1.30 per cent. of phosphorus the irregularity is not so great,

Table X.—*Specimens Stabilised at 550 deg. C.*

Spec. no.	Internal stress; gap movement. In.	Permanent set. Per cent.	*EN* value. Lb. per sq. in. × 10^6.	Tensile strength. Tons per sq. in.	Brinell hardness number.
1 ..	0.000	5.75	19.6	16.4	302
2 ..	+ 0.006	7.50	17.9	16.24	302
3 ..	+ 0.010	8.33	17.8	16.4	286
4 ..	+ 0.012	—	16.3	—	255
5 ..	+ 0.016	11.1	16.3	19.39	277
6 ..	+ 0.010	11.5	16.7	20.25	255
7 ..	+ 0.002	17.5	14.7	19.5	228

Table XI.—*Specimens Stabilised at 550 deg. C., Quenched from 875 deg. C. and Tempered at 350 deg. C.*

Spec. no.	Internal stress; gap movement. In.	Permanent set. Per cent.	*EN* value. Lb. per sq. in. × 10^6.	Tensile strength. Tons per sq. in.	Brinell hardness number.
1 ..	— 0.046	2.59	17.8	22.5	460
2 ..	— 0.028	2.21	16.5	20.8	435
3 ..	— 0.026	2.98	16.9	21.7	488
4 ..	— 0.006	5.00	16.3	22.1	488
5 ..	— 0.006	3.67	16.0	25.1	518
6 ..	— 0.036	3.24	16.19	25.7	488
7 ..	— 0.048	4.34	14.4	30.6	435

Table XII.—*Stabilised and Annealed Specimens. Hardness after Quenching.*

Specimen no.	Phosphorus. Per cent.	Brinell hardness of test rings oil-quenched from 875 deg. C. after—	
		Stabilising at 550 deg. C.	Annealing at 900 deg. C.
1	1.56	627	149 to 390
2	1.30	488	460 „ 217
3	1.06	518	518 „ 474
4	0.63	568	551 „ 518
5	0.58	568	518 „ 551
6	0.43	551	518 „ 551
7	0.035	534	320 „ 551

but is still present. The same irregularity is found in the hardened and tempered specimens. The two high-phosphorus specimens again show very little hardening effect. With up to 1 per cent. of phosphorus, a substantial hardening effect is obtained, although it is somewhat irregular.

EN Value.

These values are affected very little up to 0.63 per cent. of phosphorus. Above 1 per cent. of phosphorus they undergo a marked reduction. In the hardened and tempered condition the results show considerable irregularities.

Tensile Strength.

As already remarked, the high-phosphorus specimens show a large increase as compared with the as-cast material. A distinct increase in strength is also recorded in the medium-phosphorus specimens, whilst the low-phosphorus specimen shows a slight reduction. In the hardened and tempered condition there are very marked irregularities, some of the values being raised to an extremely high level.

Permanent Set.

These figures are very slightly modified by the annealing treatment, except in the case of the low-phosphorus specimen in which they undergo a substantial increase. As in other conditions, hardening and tempering has the effect of lowering the permanent set values.

Internal Stress.

It is very noticeable that the annealing treatment has not eliminated the internal stress, and positive gap movements are recorded in every specimen. In the case of the low-phosphorus specimen, the magnitude of the gap movement is definitely greater than that in the corresponding as-cast specimen. In the hardened and tempered condition, the change to a negative gap movement occurs, and the results show extraordinary irregularities; in some cases gap closures of nearly $\frac{1}{10}$ in., or 25 per cent. of the original gap, were obtained. The results are consistent only in the negative nature of the gap movement, and no clear relation between them and the phosphorus content is apparent.

Stress Deflection Curves.

Annealing has been accompanied by an all-round increase in the included areas of these curves. This increase is greater in the specimens containing less than 1 per cent. of phosphorus. The lowest-phosphorus specimen in this case proves an exception, and showed very little change. As in the case of the other properties, the effect of heat-treatment is somewhat irregular. Some of the specimens undergo a reduction and others an increment. The degree of curvature in all cases is substantially increased by the annealing treatment, and again this is almost completely eliminated by the hardening and tempering treatment.

Summary and General Conclusions.

A number of properties of a series of chromium alloy cast irons, containing varying amounts of phosphorus from 0.035 per cent. to 1.56 per cent., have been investigated in the as-cast, stabilised, annealed, and hardened and tempered conditions.

(1) In the as-cast condition, it is found in the specimens examined that with an increase in the phosphorus content, the Brinell hardness and *EN* value (modulus of elasticity) steadily increase, and the tensile strength, area of stress/deflection curves and permanent set value steadily decrease. The stress/deflection curves show a steadily decreasing amount of plastic curvature with increasing phosphorus. All the as-cast specimens examined show the presence of initial internal stress, characterised by a positive movement of the gap on slitting, but no relation is apparent between this and the phosphorus content.

(2) All the as-cast specimens harden to a Brinell figure of 500 and over after quenching in oil from a temperature of 875 deg. C. The maximum hardening effect is obtained in the highest-phosphorus specimens and the minimum in those with intermediate-phosphorus contents. In the hardened condition, the tensile strength is seriously reduced in all but the maximum-phosphorus specimen. The *EN* value and permanent set are likewise lowered, and the magnitude of the reduction in each case diminishes with an increase in the phosphorus.

The internal stress condition is changed completely by the hardening treatment, and is characterised by a negative gap movement, which appears to decrease in magnitude with increasing phosphorus.

(3) Tempering at increasing temperatures after hardening is accompanied by a steady reduction in the Brinell hardness. In all cases the high-phosphorus specimens retain the maximum hardness until, with a tempering temperature of 600 deg. C., all specimens show a practically uniform hardness whatever the phosphorus content. The minimum hardness with the intermediate phosphorus content persists, but irregularly, throughout the range of tempering temperatures used.

Tempering is accompanied by an immediate recovery in the tensile strength, *EN* value and permanent set value. In the case of the tensile strength, the values attain maxima substantially higher than those for the original as-cast condition. The maxima occur at critical tempering temperatures, above which the values fall to within the neighbourhood of those of the as-cast condition. The maxima attained become lower with increasing phosphorus contents, and the critical tempering temperature at which they occur shows signs of falling with increasing phosphorus contents.

Table XIII.—*Specimens Annealed at 900 deg. C. for 50 Min.*

Spec. no.	Internal stress; gap movement. In.	Permanent set. Per cent.	*EN* value. Lb. per sq. in. × 10^6.	Tensile strength. Tons per sq. in.	Brinell hardness number.
1 ..	+ 0.006	7.38	16.65	19.2	156
2 ..	+ 0.006	6.36	17.54	19.2	209
3 ..	+ 0.012	6.28	16.92	19.2	231
4 ..	+ 0.014	8.00	18.88	23.6	232
5 ..	+ 0.016	7.81	18.18	24.9	221
6 ..	+ 0.020	9.03	18.09	27.5	221
7 ..	+ 0.026	21.55	16.46	19.4	212

Table XIV.—*Specimens Annealed at 900 deg. C., Quenched from 875 deg. C. and Tempered at 250 deg. C.*

Spec. no.	Internal stress; gap movement. In.	Permanent set. Per cent.	*EN* value. Lb. per sq. in. × 10^6.	Tensile strength. Tons per sq. in.	Brinell hardness number.
1 ..	— 0.026	2.70	15.7	14.9	217
2 ..	— 0.092	3.53	15.4	18.6	255
3 ..	— 0.074	1.98	19.7	30.9	460
4 ..	— 0.064	2.73	17.5	25.6	460
5 ..	— 0.050	3.65	17.6	21.4	474
6 ..	— 0.032	2.74	16.5	25.9	488
7 ..	— 0.044	4.44	14.5	26.3	488

Table XV.—*Specimens Annealed at 900 deg. C., Quenched from 875 deg. C. and Tempered at 350 deg. C.*

Spec. no.	Internal stress; gap movement. In.	Permanent set. Per cent.	*EN* value. Lb. per sq. in. × 10^6.	Tensile strength. Tons per sq. in.	Brinell hardness number.
1 ..	— 0.034	3.17	16.5	18.8	285
2 ..	— 0.072	2.64	15.3	19.8	460
3 ..	— 0.062	2.68	18.9	26.4	390
4 ..	— 0.010	2.69	17.9	28.6	390
5 ..	— 0.012	2.14	15.9	32.4	460
6 ..	— 0.086	2.4	16.4	24.9	518
7 ..	— 0.036	3.44	13.4	27.4	460

Neither the *EN* value nor the permanent set value recover to the same values as for the as-cast condition, and they maintain the same general trend with increases in the phosphorus content. It is of some industrial importance to note the marked reduction in the permanent set value due to hardening and tempering.

The areas of the stress/deflection curves are increased, the greatest increase being in the lower-phosphorus materials. As with the strength properties, they appear to show maximum values with critical tempering temperatures. The character of the stress/deflection curves is distinctly altered by hardening and tempering at all temperatures, and the degree of plastic curvature in all specimens is substantially reduced. Almost completely eliminated at the lower tempering temperatures, this plastic curvature shows slight signs of recovery at a tempering temperature of 600 deg. C. The degree of plastic curvature in every case appears to main-

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tain the same relation to the phosphorus content as in the as-cast condition. The internal stress values maintain the negative characteristics of the hardened condition at all temperatures tested, except 600 deg. C., when they revert to the positive characteristics of the as-cast condition. The results are irregular, but in many cases the internal stress values are substantially increased by tempering. The observation of the change from negative to positive stress characteristics with increases in tempering temperatures suggests the existence of a tempering temperature where the internal stress characteristics would be zero. By interpolation these temperatures would lie between 500 deg. and 575 deg. C. for these specimens. It is not clear that the phosphorus has any influence on this.

(4) The effect of stabilising has generally been to lower the tensile strength, Brinell hardness and *EN* value. Broadly, the magnitude of the reduction is greater in the low-phosphorus specimens. In the 1.5 per cent. phosphorus specimen stabilising has not lowered the *EN* value. The properties vary with increasing phosphorus in a similar manner to those for the as-cast condition, and hardening and tempering yields approximately similar results. The internal stress condition after stabilising is somewhat unexpected, in that an increase in the positive characteristics is generally obtained. As in the as-cast condition, these are changed to negative characteristics by hardening and tempering.

A substantial increment in the stress/deflection curve area in all specimens is obtained in the stabilised, hardened and tempered condition, and again the curves show the marked reduction in plastic curvature.

(5) Annealing at 900 deg. C., under the conditions specified, has had the effect of reducing the Brinell hardness. The magnitude of the reduction increases with the phosphorus content, the high-phosphorus specimens showing a sharp fall. The annealing treatment has been accompanied generally by an increase in the tensile strength, included area of stress/deflection curves and degree of plastic curvature in these curves. The lowest-phosphorus specimen in this case proves to be the exception, and shows a slight reduction in the tensile strength and very little change in the stress/deflection curve. The permanent set value in this specimen undergoes a marked increase, but in all the others it is but slightly affected. In the case of the *EN* value, the specimens containing above 1 per cent. of phosphorus show a substantial reduction, whereas the lower-phosphorus specimens reveal very little change.

The annealing treatment has not eliminated internal stresses, and positive gap movements are recorded in every specimen. In the low-phosphorus specimens the gap movement has been definitely increased.

(6) The hardening effect in the specimens subjected to the prior annealing treatment is accompanied by irregular results in individual specimens. The degree of irregularity is greater in the specimens with over 1 per cent. of phosphorus, and becomes less in the lower-phosphorus specimens, in which the hardening effect is practically equal to that for the as-cast condition. Above 1 per cent. of phosphorus the hardening effect in the hardened and tempered specimens is irregular, and in most cases is of a very small order.

The *EN* value, tensile strength and stress/deflection curves of the annealed specimens after hardening and tempering show marked irregularities, but in general the changes are similar in direction to those in the unannealed specimens after similar treatment. In some specimens very substantial increases in strength values are obtained. In the case of the internal stress, hardening and tempering after the annealing treatment specified changes the character of the gap movement from positive to negative, and is accompanied by increments in gap movement, in some cases to extraordinarily high values.

Permission to publish these results has been granted by the Directors of the Sheepbridge Stokes Centrifugal Castings Company, Limited, in whose laboratories the investigations were carried out. The author would like to take this opportunity of publicly acknowledging his thanks to them.

Tests on Cast-Iron Girders removed from the British Museum.*

By HERBERT JOHN GOUGH, M.B.E., D.Sc.

Arising from the observations made by the Royal Commission on National Museums and Galleries on the structural condition of the British Museum, it was decided to undertake a thorough investigation into the strength of the cast-iron girders existing throughout the galleries. Three main girders and six secondary girders were received at the National Physical Laboratory for test purposes. The main girders had been cast in 1834, and were hog-shaped; the depth at the centre panel was 3 ft., the overall length was 39 ft. 8 in., and each girder weighed approximately 3.4 tons. The secondary girders were of I section, height 11¾ in., width 4 in. and overall length 16 ft.; the weight of each slightly exceeded 10 cwts.

The three main girders were tested under bending action, "four-point loading" being applied, so that the central panel of the girder was subjected to an approximately uniform bending moment. The three girders were tested in pairs, "back to back," forming a self-contained arrangement. Two girders were tested to destruction, the third unbroken, although strained, girder being saved for exhibition purposes. The six secondary girders were each tested, separately, to destruction under bending strains, four-point loading again being used. Static tensile and transverse tests were also made on a number of samples cut from the two fractured main girders and from one of the fractured secondary girders. In addition, metallurgical examination and chemical analysis were carried out on samples cut from the two main girders and one secondary girder.

The primary cause of failure of the two main girders tested to destruction was found to be due, not to any undue weakness of the cast iron, but to local unsoundness, of which the chief types were cracks in the tension flanges, blowholes and the presence of wrought-iron hooks (in the brackets provided for housing the secondary girders) used, in the casting process, to retain the moulding cores in position. All three defects were included in the face of the fracture of one girder; the fracture of the second girder included a crack and blowholes. The loads causing fracture of the girders were very low, the estimated tensile stresses in the centre of the most highly-stressed panels at fracture being only 3½ and 4 tons per sq. in. The tests revealed that the girders were in a serious condition of unsoundness; there is strong reason to believe that the cracks referred to were existing before the girders were removed from the museum floor. The experiment definitely showed that visual methods of observation cannot be relied upon to detect the presence of such cracks, even when the girder is in a state of considerable strain.

In the tests to destruction, the six secondary girders developed estimated flexural stresses at fracture varying between 9 and 12½ tons per sq. in. Although not entirely free from small defects, such as blow-holes, these girders were much sounder than the main girders. No signs of cracks were observed and the secondary girders can be regarded as being in a satisfactory condition.

The mechanical tests—tensile and transverse—made on small samples cut from the two main and one secondary girders show that the mechanical properties of the iron are satisfactory. The tensile strength of the iron, when free from defects, varies between 11 and 13¾ tons per sq. in.; the iron satisfies the requirements, both for tensile and transverse strength, demanded by British Standard Specification No. 321—1928 for Grade A Iron for General Grey Iron Castings. The results of the chemical analysis and metallurgical examination show that, although the size of the graphite flakes is somewhat coarse, yet no undesirable features are revealed which render the iron unsuitable for use in castings of this nature.

* Abstract of a Paper read before the Institution of Civil Engineers.

A Welcome Addition.

In addition to the Papers announced in our issue of April 27, arrangements have been made for an additional important Paper to be presented to the Annual Conference of the Institute of British Foundrymen which opens at Cardiff on June 20. This additional Paper is presented officially on behalf of the French Foundry Association by Mr. V. Bernard, Technical Manager of the well-known Rosières Works, and is entitled "Time Study in the Foundry."

The Paper is of a practical character and the examples are drawn from hollow-ware and light castings for the manufacture of which these works are famous.

Beryllium-Copper Alloys.

The new alloys of beryllium-copper are creating keen interest. One of the American companies which are investigating these alloys is the Pratt & Whitney Aircraft Company, of Hartford. Some facts of the company's experience were related by Mr. H. J. Noble, one of the assistant metallurgists to Mr. H. J. Fischbeck, chief metallurgist, at a recent meeting of the Hartford Chapter of the American Society for Steel Treating.

Castings of beryllium-copper containing about 2.50 per cent. Be are purchased in the "as-cast" condition from a foundry specialising in non-ferrous alloys. By special heat-treatment, unusual strength and hardness are obtainable.

The usual heat-treatment is to anneal for one hour at 790 to 815 deg. C., followed by quenching in cold water. This puts the beryllium in solid solution. Then the alloy is subjected to a precipitation hardening treatment, it being of that class of alloys, such as those of aluminium and magnesium, which have that property. Depending on the temperature for heat-treating (260 to 315 deg. C.) and the time of heating, various properties result. It is possible to obtain tensile strengths up to 67 to 80½ tons per sq. in. and a Brinell hardness of 350 to 400 by varying this treatment.

Castings of beryllium-copper, said Mr. Noble, are being used as sleeve bearings for a new adjustable Hamilton pitch propeller where there is to be as much as 6 deg. variation in rotation. The castings act as a bearing at the very high pressures involved. Increased speed is one result. Another aircraft company is using the alloy as valve guides because of its strength and its resistance to wear and heat. Henry Ford is reported to be using this new alloy in breaker points. Because of its high resistance to impact, it is being incorporated in the firing pins of firearms. The ordinary pin of alloy steel does not last more than 33 min., while one of beryllium-copper has stood up 7 hrs. in a rapid test.

XUM

Institute of British Foundrymen.

PRESTON SECTION'S VISIT TO RECONSTRUCTED WORKS AT IRLAM.

An interesting visit was paid to the reconstructed works of the Lancashire Steel Corporation, Limited, on May 24, by members of the Preston Section of the Lancashire Branch of the Institute of British Foundrymen. The response to the invitation was exceedingly good, 90 members and their friends, totalling 130 in all, attending.

Three motor coaches conveyed the party from Preston and district to Irlam, where they were welcomed by the manager, Mr. John Thornton, and his staff. It was very encouraging to see the large number of those who congregated in the fore-court of the works ready to be conducted domestic purposes.

Sections were formed, and under the expert guidance of those who knew every inch of the ground, members were conducted first through the coke-oven plant, which is so conveniently arranged between the raw material handling plant and the blast furnace, that the minimum of hand labour is required from the tipping of the slack from the wagons to the delivery of the coke to the blast furnaces. This new coke-oven plant of 51 " Becker " ovens, with their accompanying by-product plant, is capable of turning out 5,500 tons of coke per week.

Apparently the coke was not that most suitable for foundry work, and this was confirmed by the guide's statement that most of the output was used by the blast furnaces, and quite a large proportion was also sold for industrial and domestic purposes.

New Unloading Basin.

From the coke-oven plant members were directed to the new unloading basin, passing alongside the Manchester Ship Canal. There was something of a unique interest about this part of the works, owing to the fact that some few days previously Prince George had formally opened the unloading dock, and although there was not at the time a ship being unloaded, it was easy to appreciate with what speed and facility the unloading of ore and raw materials could take place.

By the forethought of the works management, members were able to see the actual breaking open of the tapping hole of one of the blast furnaces producing ferro-manganese. This was of particular interest to foundrymen, as the temperature of the metal appeared to be sufficiently high to pour some of the most intricate castings, if such were desired.

Particular attention was paid to the hot blast stoves, which have a unique arrangement whereby the gas consumption has been reduced by 25 per cent. and yet retains the maximum temperature, thereby releasing more gas for other purposes. The excess of gas required for heating up the hot blast stoves was seen to be very effectively used in the power plant generators, which have a total capacity of 10,000 kw. Some of the gas engines were of very special design, generating electrical current, and also producing the air for blowing purposes in the blast furnaces. Members were given to understand that the new blower which they saw to advantage was capable of giving 50,000 cub. ft. per min. at 15 to 20 lbs. pressure.

Reconstructed Open-Hearth Plant.

From the iron-producing plant, the visit continued to the reconstructed open-hearth plant. This consisted of steel furnaces having a capacity from 50 to 90 tons, with a large 300 tons mixer, for the reception of molten metal direct from the blast furnaces. The steel from the open-hearth plant was used for ingot making only, and these in turn were dealt with in the rolling mills, which have been completely modernised. At the time of arrival at the open-hearth plant, one 50-tons furnace was tapped, and from that point the various processes of treating an ingot were followed, through the cogging mill to a finishing mill, and finally to a unique three-high finishing mill, where the ingot had increased to an incredible length. Those of the party who were metallurgically inclined were specially interested in the " sorbitising " plant, connected to a two-high finishing mill for the production of rails. By this process the rails were given a hardened surface to that part which has to withstand the greatest degree of wear, and by a unique system of temperature control and water spray, it was claimed that with a definite depth of section a sorbitic structure of the rail was obtained.

Finally, everyone was interested in the iron and steel foundries. Although this section was not at work in the evening, it was fully employed in the production of iron and steel castings for the maintenance work of all the branches of the Steel Corporation. Those members who were connected with steel foundries passed a critical eye over the sizes of the feeding heads that were used, and it was generally agreed that judging from the proportion of head on the castings, there was nothing left to chance as far as obtaining a soundness of section in the steel castings which were produced in that department was concerned.

Votes of Thanks.

The visit concluded in the canteen of the works, where very welcome refreshments were given to members. It was here that Mr. West, President of the Preston Section, thanked the management of the Lancashire Steel Corporation, particularly Mr. John Thornton, the manager, for the generous way in which they had treated the members. In asking the members to pass a vote of thanks to those who had so kindly provided everything, the President remarked upon the atmosphere of efficiency, even down to the cleanliness of the by-paths in and about the works, which were all indications of the progress that was being made in the reconstruction of the old Partington Steel and Iron Works.

Mr. Phillips, the President of the Lancashire Branch, seconded the motion, which was acclaimed with great heartiness by the members. Mr. John Thornton said that it was the policy of the firm to encourage anything in the way of technical interest, by conceding to any request by such bodies as the Institute of British Foundrymen to visit their works, and he would go further and state that parties of two and three of those men who had more than a common interest in their works, would be welcome and shown the same courtesy and consideration as was given to the larger bodies of men who visit their works from time to time.

International Foundry Congress.

PRAHA (PRAGUE), SEPTEMBER 9 TO 16, 1933.

The Czecho-Slovak Foundry Association was founded in 1923 as a technical association devoted to the study of problems connected with foundry practice. The Association has about 400 members, including 60 foundries. There are four regional sections of the Association, namely, Praha, Brno, Plzen and Moravská Ostrava. The beginning of the cast-iron industry of Czecho-Slovakia can be traced as far back as the 16th century. At the present time there are about 400 foundries in Czecho-Slovakia. These are partly independent and partly connected with large engineering or metallurgical plants.

The International Foundry Congress will be held under the auspices of the Government of the Republic of Czecho-Slovakia. Its opening and sessions will take place in Praha, the capital of Czecho-Slovakia. The Annual Assembly of the Czecho-Slovak Foundry Association and the Meeting of the International Committee of Foundry Technical Associations will be held in connection with the International Congress. Arrangements are being made for visits to some important industrial plants in Praha and the vicinity, as well as for sightseeing trips through Praha and surrounding country.

Members of the Congress will have the opportunity to visit the Prague Autumn Fair (September 3 to 10) and the exposition of ornamental and artistic castings. At the finish of the sessions in Praha, excursions to the noted industrial districts of the Czecho-Slovak Republic will be undertaken. A special train of the Czecho-Slovak State Railways will be at the disposal of the members, thus eliminating the annoying loss of time and affording pleasant and comfortable travel at reduced rates.

The industrial centres to be visited are.—Moravská Ostrava: Inspection of large iron works, foundries, coke plants and coal mines; Zlín: Inspection of the Bata Shoe Factory; Brno: Inspection of industrial plants and sightseeing trips through the city and its surroundings; Plzen: Inspection of industrial plants enumerated in the programme. The members of the Congress will have an excellent opportunity to visit—while in Czecho-Slovakia—the famous watering places Karlovy Vary (Carlsbad), Mariánské Lázne (Marienbad) and Jáchymov (Joachimstal).

Preliminary Programme.

Saturday, September 9.

Arrival of Congress members in Praha. Registration. Room accommodations.
Official opening of the Congress.
Reception by the Mayor of Praha.

Sunday, September 10.

Lectures on technical subjects.
Afternoon: Sightseeing tour through Praha. Visit to the Exhibit of artistic iron castings. Excursions in groups.

Monday, September 11.

Inspection of industrial plants in groups.
Afternoon: Departure for Moravská Ostrava.

Tuesday, September 12.

Group I: Inspection of smelting plant of the Vítkovice Mines, Steel & Iron Works Corporation.
Group II: Inspection of the smelting plant of the Mining & Iron Works Company at Trinec.
Afternoon: Inspection in groups of coal mines and coke plants of the Ferdinand Northern Railway Company (coal pit " Frantisek "), and of the Mining & Iron Works Company (coal pit " Ignat ").
8 p.m.: Informal dinner.

Wednesday, September 13.

Departure for Zlín. Inspection of Bata Shoe Factories.
Departure for Brno.

Thursday, September 14.

Inspection of industrial plants in Brno and sightseeing tour through the city (in groups).
Afternoon: Departure for Plzen.

Friday, September 15.

8 a.m.: Inspection of the foundries of the Skoda Works Company, Limited.
Afternoon: Visit to the Citizens' Brewery (Pilsner Beer) in Plzen.

Saturday, September 16.

Excursion to the West Bohemian Kaolin and refractory plant at Hornf Bríza.
8 p.m.: Closing banquet in Plzen.

Sunday, September 17.

Departure. Arrangements may be made for trips to the famous Czecho-Slovakian watering places: Karlovy Vary (Carlsbad), Mariánské Lázne (Marienbad) and Jáchymov (Joachimstal).

First Report of the Steel Castings Research Committee.

By a Committee of the Iron and Steel Industrial Research Council.

[*Abstract.*]

(*Concluded from page* 390.)

Discussions of Results and Conclusions.

In the previous sections of the Report, a description has been given of the manner in which characteristic defects in castings, designed to withstand severe conditions of service, were affected by experimental variations in the method of manufacture. In approaching the manufacture of such castings, and also of others of simpler pattern, the founder is confronted by a series of difficulties, which may be included under the following headings:—(1) The natural difficulties depending on the unalterable physical properties of fluid and solid steel, and necessarily encountered in the production of a sound and homogeneous mass of solid steel of whatever form; (2) difficulties associated with the requirements of the design, some avoidable by modification of the details, but others inherent in any design for a casting which would fulfil the desired functions; and (3) economic difficulties imposing limitations on the measures which may profitably be adopted, whether by modification of design or of method of manufacture, to counteract the adverse influences of contraction and segregation.

The solidification and subsequent cooling of steel in a mould are necessarily accompanied by certain phenomena which have inevitable effects in the casting produced. The contraction on solidification and on subsequent cooling leaves cavities in regions which solidify later than the surrounding parts, and also induces tension in parts which, on account of their form, are prevented by the mould from contracting freely. In a range of temperature below the solidifying point steel is both weak and fragile, and is thus readily cracked in tension. Solidification proceeds by differential freezing which concentrates carbon and impurities in the last solidifying parts and thus produces segregation. The founder endeavours to restrict these various inevitable defects within the runners and risers, but often the design of the casting does not permit of this aim being fully realised, as the provision of completely adequate feeding heads would so increase the cost as to be prohibitive. Even in steel ingots (which are the simplest forms of castings) intended for hot-working, the effects of contraction and of segregation have to be accepted up to a certain point. In large quantities of run-of-work steel castings, not required to withstand important stresses, cavities and discontinuities in moderation do not in any way reduce the serviceability of the casting, and may accordingly be accepted.

There are, however, many castings in which the restriction of weight and the relatively severe conditions of use necessitate a much closer approach to complete soundness. This feature is illustrated by the branch-piece casting which was studied in considerable detail. Freedom from cavities could only be attained by suitably placed and sufficient heads. A correct distribution of the heads proportioned to feed successive regions of the casting proved to be of prime importance. No increase in size could compensate for inadequate distribution of the heads; in many castings each section is virtually a separate ingot and must be treated as such. Given adequate distribution, the attainment of soundness, however, depended upon the use of a minimum weight of head, which amounted in this instance to at least 40 per cent. of the total metal cast. It also involved a minimum area of gates which precluded the use of long and narrow heads or of heads constricted at the lower end to facilitate removal.

Freedom from cracking was more difficult to attain on account of certain features of the design. The solidifying steel is securely held in the mould by the end flanges while contraction stresses accumulate in the thin wall and finally lead to circumferential cracking in the thick bulkhead flange where the temperature of the steel remains higher than elsewhere in the walls during cooling. This objection was foreseen in several opinions expressed before the series of experiments was started, and objection was fully justified by the results. Cracking at the bulkhead flange was the most serious difficulty which had to be overcome. It was influenced by the position of the runner, being greatly accentuated when the metal was run into the bulkhead flange, thus still further maintaining its high temperature in relation to the surrounding metal, and minimised when the metal was run at the wall between the flanges or at one of the end flanges. When the runner was situated in an end flange, there were often signs of cracking round the junction of the wall and flange at which the casting was run. In eliminating the cracking no single factor appeared to be more effective than the filling of the mould as rapidly as possible, if necessary continuing to feed the heads as solidification occurred. The introduction into the mould of a body of metal as nearly as possible at a uniform temperature, and adequately fed as solidification proceeded, appeared to provide conditions having the most pronounced effect in the direction of the elimination of cracking. Even so, additional strengthening by internal brackets was necessary to ensure absence of cracking.

It became clear that the natural difficulties arising from the behaviour of steel during solidification could be overcome, provided that little regard was paid to the cost of the procedure —for example, by making the castings solid and subsequent boring out—but that within a reasonable increase in cost the occurrence of defects could only be obviated by modification of design. This raises the often-discussed question of lack of co-operation between designer and founder. Examples could be multiplied in which slight alterations to the design, such as thickening a wall at one position or reducing the section at another, the introduction of fillets or the cutting down of extravagant fillets, the equalisation of wall thickness at a junction or the lessening of the gradient of a change of section, have made all the difference between success and failure.

There are well-understood principles which govern these details, though these principles are not reducible to the same relatively simple form as are those which govern the manufacture of sound ingots. They are rather deductions from the most probable behaviour of the steel in the mould during solidification, and they are nearly always suggested and if possible applied by the founder. Less obvious and more difficult to arrange are those modifications of design which would result in cheaper pattern-making, less intricate, and therefore less expensive, moulding and a decreased risk of failure to secure a regular production of sound castings. These modifications are not likely to be made or suggested by the expert founder, who would not regard the demands of an intricate and difficult design as anything but a tribute to his skill; but even if the production of the more complicated castings is a possibility, it should be proved a necessity before the additional expense involved is entailed.

Direct contact between the founder and the designer is not likely to lead to the greatest simplification; a third person, of independent status, is most likely to reconcile the essential demands of the one with the possible achievement of the other, and to modify the design in a manner which makes it both practicable and economical without impairing its utility. It has recently been suggested that the metallurgist is the most appropriate link between the designer and founder, and certainly anyone who attempts to fulfil this function, whether metallurgist, engineer or foundry superintendent, must do so by virtue of sound metallurgical knowledge. Some designs are put forward for castings which could by no conceivable means be made sound. In the present state of development of the steel castings industry it is therefore not too much to say that the next essential step in progress is in the design of castings.

The beneficial effect of the most striking advances in design may, therefore, be completely lost by inadequate safeguards in the way of the feeding and gating of castings enforced by an undue insistence on cheapness. If the very high standard demanded for highly-stressed castings is to be maintained, it must be recognised that this standard is not easily attained, but that it involves a definite heavy outlay in special control of sands, make-up of moulds and cores, and in providing adequate feeding of the casting. It must also be admitted that the system of competitive tenders is apt to tempt steel founders to quote prices which may not fully allow for this heavy outlay, and then to avoid loss by undue economy in the provision of the safeguards mentioned.

When essential requirements under these three headings are recognised, the way is cleared for the more quantitative application of scientific principles to the manufacture of castings. This can only be made possible by a knowledge of the fundamental properties of the materials employed for both metal and mould. Though much remains to be done in the way of detailed investigation of the physical characteristics of these materials, important contributions to the knowledge of their properties are found in the publications referred to in the bibliography appended.

A difficulty in the way of the rigid application of scientific principles in the steel castings industry is that every new design of casting is virtually a distinct and individual problem in itself, and therefore, even when the fullest physical data are available, an element of judgment will remain indispensable.

SELECTED BIBLIOGRAPHY.

The following short bibliography contains references to some of the more important Papers on aspects of the subject dealt with in the foregoing Report. No reference is made to such matters as steel-making, the properties of moulding sands, special casting processes such as centrifugal casting, or to alloy-steel castings and their heat-treatment. The items are arranged in groups under the headings:

(*A*) Uses of steel castings and prospects of the steel castings industry.
(*B*) Properties of steel castings.
(*C*) Steel foundry practice.
(*D*) Defects in steel castings.
(*E*) Radiological examination of steel castings.

(A).—*Uses of Steel Castings and Prospects of the Steel Castings Industry.*

(1) J. B. SEDGWICK: "Admiralty Requirements in Steel Castings." Proceedings of the Institute of British Foundrymen, 1928–29, Vol. 22, pp. 591–599; FOUNDRY TRADE JOURNAL, 1928, Vol. 39, pp. 357–358.
Deals mainly with marine engine castings, especially those exposed to high pressure and superheated steam.

(2) G. E. WELLS: "The Real Steel Foundry Problem." FOUNDRY TRADE JOURNAL, 1929, Vol. 41, p. 341.
Economic considerations which confront the maker of steel castings.

(3) C. B. HARBISON: "Economic Value of Steel Castings as Materials of Construction." Iron Age, 1930, Vol. 126, pp. 279–282.
Instances given in which steel castings can with advantage replace welded and riveted structures, especially in locomotives.

(4) R. SCHAFER: "Steel Castings as Material for Construction." Giesserei Zeitung, 1930, Vol. 27, pp 205–214, 243–252, 272–285.
Provisions of the German standard specification for steel castings, DIN.1681, are discussed in detail.

(5) F. W. DUESING: "Steel Castings as Material for Machine Construction." Stahl und Eisen, 1930, Vol. 50, pp. 438–440.
The tensile properties of steel castings and their suitability for machine parts are briefly discussed.

(6) R. KRIEGER: "Developments and Prospects of the German Steel Foundry Industry." Stahl und Eisen, 1930, Vol. 50, pp. 421–422.

For abstract of the above Papers 5 and 6, see Metallurgist, 1930, Vol. 6, pp. 68–69.

(7) "Steel Castings." Engineer, 1931, Vol. 151, pp. 161–162.

A comparison of steel castings with forged and welded structures, giving the relative merits of both.

(8) G. P. ROGERS: "Statistical Data on Steel Castings Production in the United States." American Foundrymen's Association (Symposium on Steel Castings), June 21, 1932.[1]

Consumption of steel castings in various industries in U.S.A.

(9) R. A. BULL: "Purchase Requirements for Steel Castings, with Notes on Physical Properties in Test Bars and in Commercial Castings." American Foundrymen's Association (Symposium on Steel Castings), June 21, 1932.[1]

The provisions of American and other specifications for steel castings are discussed in detail.

(B).—*Properties of Steel Castings.*

(1) J. O. ARNOLD: "The Properties of Steel Castings." Journal of the Iron and Steel Institute, 1901, No. I, pp. 175–195.

A preliminary survey, in which small cylindrical bar castings were used, with the object of determining the influence of the chemical composition and heat-treatment on the mechanical properties and structure of castings. The occurrence of sulphide films, and the effect of annealing in causing them to "ball up," are noted. This Paper is of interest as the first important systematic investigation of the influence of annealing on the structure and properties of steel castings.

(2) J. JEFFERSON: "Some Notes on Steel Castings." Journal of the West of Scotland Iron and Steel Institute, 1921–22, Vol. 29, pp. 53–59.

Effect of composition, casting temperature and heat-treatment.

(3) P. OBERHOFFER: "The Properties of Steel Castings." Zeitschrift des Vereines deutscher Ingenieure, 1923, Vol 67, pp. 1129–1133.

Influence of chemical composition, duration of annealing, and rate of cooling on the mechanical properties. Correlation of these with structures.

(4) F. KORBER and A. POMP: "Mechanical Properties of Cast Steel at High Temperatures." Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung, 1928, Vol. 10, pp. 91–105; Stahl und Eisen, 1928, Vol. 48, pp. 1321–1330: abstract, Metallurgist, 1929, Vol. 5, p. 43.

Continuation of previous work to which references are given. Mechanical tests over the temperature range 20 deg. to 500 deg. C. on 12 steels of varying composition produced in the open-hearth, converter, and electric furnace. The influence of position of test-piece in the casting on the notched-bar test is also investigated.

(5) A. WALLICHS and K. KREKELER: "Cast Steel and Machinability." Die Giesserei, 1930, Vol. 17, pp. 325–329.

Curves and tables showing the machinability in the lathe of carbon and alloy cast steels. The influence of chemical composition, melting practice and casting skin is considered.

(6) A. POMP: "Ageing of Steel Castings." Stahl und Eisen, 1930, Vol. 50, pp. 440–441.

Tests were made on steels containing carbon 0.11 to 0.27, and manganese 0.45 to 1.37 per cent., in both the annealed and tempered conditions. The steels were given 7 to 10 per cent. compression followed by heating at 250 deg. C. for 1 hr. for ageing. The notched-bar figure showed a falling-off in the aged condition, but to a greater degree in the annealed than in the tempered specimens.

(7) A. THUM and H. HOLDT: "The Strength of Cast Steel at High Temperatures." Die Giesserei, 1930, Vol. 17, pp. 333–339.

Short-time creep tests on two cast steels, carbon 0.2 and 0.36 per cent.

(C).—*Steel Foundry Practice.*

(1) G. F. PRESTON: "Practical Notes on the Design and Treatment of Steel Castings." Journal of the Iron and Steel Institute, 1920, No. I, pp. 389–400.

Modifications of design to meet founders' requirements; defects and their avoidance; test-pieces; heat-treatment.

(2) H. OEKING: "Designs of Steel Castings." Stahl und Eisen, 1923, Vol. 43, pp. 841–845.

General practice in the design and moulding of steel castings. Avoidance, whenever possible, of horizontal surfaces as these lead to entrapped air.

(3) J. H. HALL: "Proportioning and Shaping of Sink Heads." Iron Age, 1924, Vol. 114, pp. 822–823.

The correct shape, proportion and position of sink heads for steel castings are discussed. The use of cone-shaped heads is advocated.

(4) F. A. MELMOTH: "Some Metallurgical Points in Electric Steel Castings." FOUNDRY TRADE JOURNAL, 1925, Vol. 32, pp. 549–552.

Single and double slag processes of working in electric furnaces are compared, and causes of lack of fluidity in the steel discussed. The nature of defects such as porosity, contraction cracks and cavities, draws, and blowholes, is outlined.

(5) L. TREUHEIT: "Steel Foundry Practice." Stahl und Eisen, 1927, Vol. 47, pp. 2101–2112.

Influence of mould and mould material on the successful casting of complicated patterns. Investigation of the materials and methods used.

(6) F. A. MELMOTH and T. W. BROWN: "The Manufacture of a Large Steel Casting." FOUNDRY TRADE JOURNAL, 1927, Vol. 36, pp. 19–22, 45–48: Proceedings of the Institute of British Foundrymen, 1926–27, Vol. 20, pp. 232–257.

Full description of the moulding, pouring and treatment of a large cast propeller-shaft bracket.

(7) A. RHYDDERCH: "The Feeding and Gating of Steel Castings." FOUNDRY TRADE JOURNAL, 1927, Vol. 36, pp. 233–236.

Discussion of the most suitable methods of gating and feeding of steel castings in the light of the behaviour of steel during solidification and cooling.

(8) J. JEFFERSON: "Steel Castings from the Moulder's Viewpoint." Proceedings of the Institute of British Foundrymen, 1928–29, Vol. 22, pp. 623–632: FOUNDRY TRADE JOURNAL, 1928, Vol. 39, 393–394.

Importance of design, heat-treatment, methods of inspection and taking tests, economic considerations.

(9) A. MCCANCE: "The Metallurgy of Steel Castings." Proceedings of the Institute of British Foundrymen, 1928–29, Vol. 22, pp. 607–622: FOUNDRY TRADE JOURNAL, 1928, Vol. 39, pp. 465–466; 1929, Vol. 40, pp. 25–26.

Contraction in steel castings in the liquid state, during freezing and during subsequent cooling.

(10) "Conference on Steel Castings." FOUNDRY TRADE JOURNAL, 1929, Vol. 41, pp. 279–280.

Report of conference following symposium on steel castings in Glasgow.

(11) C. H. KAIN: "Steel Castings." FOUNDRY TRADE JOURNAL 1929, Vol. 41, pp. 403–404, 422–425.

Deals with the careful control needed in electric steel for foundry work to keep down the FeO content, as this is stated to produce "lack of life." Test-bars for steel castings and various moulding problems are discussed.

(12) T. M. SERVICE: "Steel Castings." FOUNDRY TRADE JOURNAL, 1930, Vol. 42, pp. 266–268, 291–292.

Description of types of defect, blow-holes, piping, shrinkage cavities and segregation, occurring in steel castings; importance of design and methods of running. An abstract of Korber and Schitzkowski's paper (*D4*) is given.

(13) P. R. RAMP: "Steel Castings in Green Sand." Iron Age, 1930, Vol. 125, pp. 711–713.

Describes mixing of sand, venting of mould, gating of casting heads, and methods of pouring in green-sand work.

(14) F. A. MELMOTH: "Some Metallurgical Points in Acid Open-Hearth and Electric Steel for Castings." Transactions of the American Foundrymen's Association, 1931, Vol. 39, pp. 458–495.

Physical and microscopical comparison of steels made by the acid open-hearth and electric processes. The steels were of closely comparable chemical composition, and were given identical heat-treatment.

(15) F. A. LORENZ, JUN.: "Notes on the Design of Steel Castings." American Foundrymen's Association (Symposium on Steel Castings), June 21, 1932.[1]

Co-operation between designer and founder in avoidance of defects; factors influencing cost.

(D).—*Defects in Steel Castings.*

All Papers under Section C deal, incidentally, with defects in steel castings and methods for avoiding them. The following are more descriptive or deal more fully with some particular type of defect.

(1) F. J. STANLEY: "Defects Hiding in Steel Castings." Iron Age, 1926, Vol. 118, pp. 12–13, 60–62.

Types of defects, porosity, blow-holes, shrinkage and cracks, with discussion of the means for their prevention.

(2) H. MALZACHER: "The Straining of Steel Castings on Shrinking in the Mould." Stahl und Eisen, 1926, Vol. 46, pp. 1013–1017. "Shrinkage Stresses in Steel Castings." Stahl und Eisen, 1927, Vol. 47, pp. 2108–2112.

General observations on the stresses set up, and forces exerted due to shrinkage. The effects produced in castings and methods of reducing them are discussed.

(3) K. SINGER: "Thermal Cracks in Steel Castings." Die Giesserei, 1928, Vol. 15, pp. 1225–1229.

Origin of hot cracks, and means for their prevention.

(4) F. KORBER and G. SCHITZKOWSKI: "Shrinkage of Steel Castings." Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung, 1927, Vol. 9, pp. 279–294: Stahl und Eisen, 1928, Vol. 48, pp. 129–135, 172–178: Abstracts, Metallurgist, 1928, Vol. 4, pp. 55–56: FOUNDRY TRADE JOURNAL, 1928, Vol. 39, pp. 47–48.

The process of shrinkage of steel castings during freezing and subsequent cooling was followed. All those castings in which shrinkage was impeded showed cracks immediately after cooling below the point of solidification, that is, at a temperature of about 1,300 deg. C. Methods of avoiding shrinkage cracks are discussed. The best and usual method is to loosen or break up the mould immediately the metal has set, that is, before it cools below about 1,300 deg. C. Thin castings are likely to reach this temperature within one minute after pouring. If the thickness is 2 in. or over, 6 to 8 min. can be allowed.

(5) G. F. GILLOTT: "Critical Examination of Steel Castings." Proceedings of the Institute of British Foundrymen, 1928–29, Vol. 22, pp. 426–452: FOUNDRY TRADE JOURNAL, 1929, Vol. 41, pp. 38–40, 59–60.

Macroscopical and microscopical methods of examining the structure of steel castings are described, and various types of defect illustrated.

(6) C. H. KAIN: "Notes on Some Common Defects in Steel Castings." FOUNDRY TRADE JOURNAL, 1933, Vol. 48, pp. 95–96, 108–110.

Discussion of cracks, contraction cavities and blow-holes in relation to the design of the casting, properties of the metal and design of the mould.

(E).—*Radiological Examination of Steel Castings.*

(1) H. H. LESTER: "X-Ray Tests Applied to Problems of the Steel Foundry." Transactions of the American Society for Steel Treating, 1924, Vol. 6, pp. 575–605.

A comprehensive summary of the types of defects found in steel castings is given. Radiographs and corresponding photographs after sectioning are reproduced in typical cases.

(2) V. E. PULLIN: "X-Ray Examination of Steel Castings." Proceedings of the Institute of British Foundrymen, 1928–29, Vol. 22, pp. 600–605: FOUNDRY TRADE JOURNAL, 1928, Vol. 39, pp. 358–359, 415–417.

(3) A. ST. JOHN: "X-Ray Inspection of Castings." Fuels and Furnaces, 1929, Vol. 7, pp. 1371–1372, 1407.

Examples are given of actual commercial inspection of steel castings with X-rays. Rejections have been made in America on radiographic evidence.

(4) V. E. PULLIN: "X-Rays in Engineering Practice." Engineer, 1930, Vol. 150, pp. 686–688.

Includes examples of defects in steel castings revealed by X-rays.

(5) V. E. PULLIN: "X-Ray Examination of Castings." FOUNDRY TRADE JOURNAL, 1931, Vol. 44, pp. 23–24.

(6) C. W. BRIGGS and R. A. GEZELIUS: "Detecting Defects by Radiography using Gamma Rays." Transactions of the American Foundrymen's Association, 1931, Vol. 39, pp. 65–92.

The use of gamma rays from radium for the detection of internal defects in steel castings is discussed. Examples are given of the application of the method in work directed towards the improvement of steel castings.

(7) V. E. PULLIN: "Examination of Metals by Radium." Engineer, 1932, Vol. 153, pp. 492–494.

Advantages and disadvantages of radium compared with X-rays for the detection of internal flaws in metallic objects. Examples of radiographs obtained by both methods from steel castings are given and the relative merits of each are illustrated.

[1] A full report of this important "Symposium on Steel Castings" is contained in the Proceedings of the American Society for Testing Materials, 1932, Vol. 32, Part II, pp. 43–268.

[1] See footnote, previous column.

The Spelter Situation.

By "ONLOOKER."

During the hectic upward movement seen in the base metals during the past few weeks spelter has rather lagged behind the others, and whereas both copper and tin have increased in value to the extent of about 50 per cent., the rise in spelter has not been more than 15 per cent. For one thing, zinc has not attracted the speculator in the same way as copper and tin, and in consequence the rise has been kept within reasonable limits, the price at the time of writing being £16 17s. 6d., which, although it is the highest point touched this year, compares with the lowest since January of £13 10s. Last year, of course, saw a considerably lower level than this, for £10 10s. was touched in April, and it was not until curtailment was brought down to 45 per cent. of capacity that the market began to develop a better tendency.

Statistically the spelter position has improved very considerably during the past twelve months or so, but the uncertainties surrounding the cartel have kept a rise in check, and even now after a scare in the early part of the year there appears to be some doubt about the arrangement continuing after July. Fears of a breakdown certainly have not disturbed the market of late, for during the last ten days of May values advanced by 20s., and consumers have shown more enthusiasm than for a long time past, even the galvanising trade taking more metal than usual. In regard to this, one must remember that consumers of spelter, in common with other metals, have been replenishing stocks which have been allowed to run down to danger point as long as it seemed possible that any further reaction in values were likely, but with the change in sentiment, and particularly the tendency to transfer from currencies into commodities, users have to some extent departed from their practice of sticking rigidly to a hand-to-mouth policy of purchasing. The importance of this change of front cannot be overestimated, for it is the first real sign of returning confidence, and it should make it possible for producers to carry on without the haunting fear that stocks will accumulate on their hands.

It is early yet to say how much of the recent improvement in spelter values will be maintained, and consumers are naturally buying very cautiously at the higher levels, for they have not yet accustomed themselves to what appears at the onset to be a somewhat inflated value. In this connection the events of the next few weeks are of the utmost importance. At the same time it does appear that the galvanisers are rather busier than they were, and reports from South Wales suggest that spelter is passing into consumption more freely. This applies mainly to G.O.B. quality, and owing to quiet times in the brass trade the call for high grade is not at all good, although here again there has been some improvement of late.

Perhaps one of the best points about the spelter situation is the fact that while production has been controlled under the ægis of the cartel, no attempt has been made to hold up the price or to manipulate the market in any way. This might well have been attempted, for since the application of the 10 per cent. duty on foreign metal, this country has been virtually reserved to the Empire producers, and in consequence the grip on the London quotation has tightened considerably, being vested in the hands of those interests responsible for marketing this metal. Foreign spelter has as a matter of fact come into this country, some of it going into bonded warehouse and some into consumption in spite of the duty, and presumably now that the price stands at a better level for the producers, still more will be arriving and competing with the Empire brands. This is all to the good, for during the past twelve months or so there has been a tendency for the premiums on spelter from Canada and Australia to increase.

Foundry Selling Practice.

By Eric N. Simons.

If you asked most founders whether or not they regarded an order as an opportunity, they would answer affirmatively, meaning thereby that they looked upon orders as a chance to show what they could do. But having said this, it would amaze an impartial investigator to discover how frequently they overlook the opportunity side of the business they get. It is not implied that they fail to deliver goods in accordance with the needs of the customer, but that they only too often overlook all sorts of opportunities over and above the mere chance to prove ability. It will be as well to examine in this article what these are and how to make the most of them.

First of all, the order is, reduced to its elements, a tangible indication of a number of things:—(*a*) That the customer has a use for a particular product or casting; (*b*) that the supplier has succeeded in convincing the buyer that his type of casting gives something the customer cannot, or doubts if he can, get elsewhere; (*c*) that the efforts of the firm's publicity and sales promotion staff, and of its salesmen, have succeeded in bringing the order to its door; (*d*) the very presence of the order on the books signifies that the firm is meeting a particular need, which may be duplicated, not only by this one customer, but by others; and from all these things there is something to be learned, something of material value to the firm's business.

What happens in most foundries? The order comes. It is formally acknowledged, often on a printed card of stereotyped phraseology. It goes through the books and down into the works, passes through the various stages, and is executed. How it is executed, whether ill or well, is of no concern at the moment. The point is, that it has become a piece of routine, just as much as an inquiry or a quotation. It appeals to nobody's imagination as a means of getting into close touch with that particular customer, and of finding other customers.

Acknowledgment of Orders.

This state of affairs can only be remedied by taking the order out of the groove of routine and letting the sales department treat it with some intelligence. The acknowledgment is the first thing needing to be attacked. If orders are so numerous that it is impossible to acknowledge each by individual letter, as would be the ideal, then let the formal acknowledgment have a little of the arresting about it. One foundry prints a facsimile advertisement of some other product on the acknowledgment card, preferably an illustrated advertisement, and finds that it occasionally receives orders as a result. Such facsimiles can easily be made as half-tone or line blocks from good pulls or reproductions of advertisements. Another foundry sends treatment instructions in the form of little printed leaflets with every acknowledgment. A third pays special attention to the wording of the acknowledgment, and has a card reading thus:—

"In acknowledging receipt of your order No. . . . of . . . we express the hope that this is either the beginning of pleasant and mutually helpful relations between us, or the continuation of those friendly relations that have existed in the past.

"We are giving your order all our care. Should you have any occasion to write to us about it, address your letter for the attention of Mr. . . . who will see that your queries are dealt with promptly."

This wording is varied from time to time, in order that it shall not stale, but the substance is pretty much the same. The firm has found that in the majority of instances letters concerning orders are marked by the customers for the attention of the official designated. This proves that the acknowledgments are read, and saves much time at the foundry end.

Nothing, of course, should be allowed to hold up the proper execution of the order, neither its listing for representatives, nor its recording for sales purposes. But once the order department have transferred it to their books, it should pass to sales department (or other deputed officials) for analysis from the point of view of the opportunities it affords. For instance, a primary requisite of any and every foundry sales department is a classification of customers according to their requirements. This is required for circularising purposes, for sales analysis in representatives' districts, and for other purposes that need not be detailed. Obviously, if a firm selling castings for dredger work, for example, brings out a new material for these castings, it would be waste of time to circularise every casting purchaser on the books, since the majority would probably have no use whatsoever for dredger castings of any material. But all purchasers of dredger castings would need to be circularised, and this could not be done unless an analysis of the type indicated were at hand and kept up to date.

Market Analysis.

But even more important than this is the analysis of markets. Let an example be chosen to illustrate this. Every purchaser of castings has a use for the castings he buys, and for every purchaser who has a particular use there is probably a competitor of his who has an identical use, and to whom similar castings could be sold. Suppose, for argument's sake, the engineer of a large water-scheme places with a foundry, after certain inquiries, an order for cast-steel pipe castings. Is the foundry, having executed the order satisfactorily, to sit down and wait for repeat orders? Is it not rather its business to hunt up every other water engineer in the country, or the world, and shower upon him arguments for using steel-pipe castings in future?

It is probable that there is no type of opportunity more frequently neglected, not only in foundries, but in every engineering business personally known to the author. A firm orders castings for a specific job—it may be for pug-mill knives for making bricks, or for tyre moulds for making automobile tyres. Does the founder at once note down brickworks as a market for manganese castings or tyremakers as a market for castings? In one or two instances, perhaps, this is done. But is it in every instance, for obviously it ought to be done if selling is to be efficient. Every order received should be analysed from the point of view of its bearing on future sales. Here is an order for castings from a steel roller. What are the castings for? They are for rolls for rolling a specific type of steel. The founder should at once ascertain if any other firms roll similar steels, and set to work to sell them castings for the rolls. He should find out if the castings succeed, and push them for all they are worth if they do. If he does not know the purpose for which they are to be used, he should discreetly try to find out. If he cannot, he has at least the clue that *X* in such and such an industry has a use for castings, and can try the experiment of pushing castings among other firms in the same industry.

Then there is the analysis of the order from the point of view of selling the customer something else that a firm makes. He orders, for example, iron castings in the rough, and from the drawings he sends it is known that machining work is to be done on those castings. It may be that the foundry happens to make machine tools as well as iron castings. Here, surely, is a possibility of introducing a new machine for machining, drilling, boring, turning, or whatever it may be, iron castings. Or there is a customer for steel castings, and the supplier sells tool steel as a side-line. Surely one can introduce one's own tool steel to a casting customer. Or the firm may have a subsidiary company that sells lubricants. There are endless possibilities of increasing business by analysing the order as a possible outlet for one's own products. A customer may order brass castings for a particular job, and experience of that work may indicate that if he uses brass castings he must also use some other type of casting in which the supplier is interested. Here is a chance to approach him, if that has not already been done. Too often one hears a customer say: "Well, I've bought my castings from you for years, but I never knew until just now that you made so and so as well."

Probing for Pointers.

Next there is the analysis of the order from the point of view of its giving a clue to successful selling points. This involves going into the history of the order, noting down from correspondence or representatives' reports just what points were in suspense, what arguments, concessions, promises or technical points brought in the order. There can be no question as to the value of an analysis of this kind. It not only provides salesmen and publicity men with the best possible material for their selling work, but also furnishes the technical men with possibilities of improvement or alteration. Furthermore, from the point of view of the sales department, it is a valuable indication of the market trend. If in nine instances out of ten the price clinched the order, then obviously price is the predominant current selling factor, and both selling policy and product must be adapted accordingly. If, on the other hand, it is quality, or technical advantage, or performance, then again the barometer points to the steps that must be taken.

Enough has been said—though more could be written—to indicate some of the possibilities inherent in the obtaining of an order and the manner in which they can best be put to use.

Legal.

Mr. Justice Du Parcq, in the King's Bench Division on May 31, gave judgment in the action by Mr. Frederick Charles Fairholme against Messrs. Thos. Firth & John Brown, Limited, steel manufacturers, of Sheffield.

Plaintiff's case was that on the amalgamation in 1931 he was appointed a joint managing director at a salary of £8,500 per annum for a period of 4½ years, but his services were terminated before the period expired.

It was stated that the parties had now agreed to a figure of £18,000, subject to adjustment by the Court, and defendants urged that any damages awarded would not be subject to income tax, consequently this should be deducted, otherwise the plaintiff would be in a better position than if he were still in the employment of defendants. Defendants further said that in 1931 plaintiff agreed to accept 10 and 5 per cent. reductions, and that this should be taken into consideration. Defendants admitted that there was not the slightest reflection on plaintiff's character.

His Lordship found in favour of plaintiff in regard to deduction of income tax, and the 15 per cent. "cut," and that he was entitled to £18,000, the agreed amount. Stay of execution was granted on the application of defendants, subject to the payment of £10,000 to plaintiff and the balance of the amount of £13,500 paid into Court being deposited in a bank in the joint names of the solicitors representing the parties.

This Week's News in Brief.

Trade Talk.

TANGYES, LIMITED, Cornwall Works, Birmingham, have just secured an important order for a 4,628-ton hydraulic press, together with the necessary pressure pumps and other equipment.

THE KEELS have been laid at Messrs. Hawthorn, Leslie & Company's shipyard, Hebburn-on-Tyne, of two sloops ordered by the Portuguese Government. Two sloops previously ordered are being completed.

MESSRS. WORKMAN CLARK (1928), LIMITED, of Belfast, have secured a contract from the Ellerman Line to recondition four large vessels and fit them with turbo-electric machinery.

MESSRS. ROBERT DEMPSTER & SONS, LIMITED, Rose Mount Ironworks, Elland, Yorks, have opened an office at 16, Queen Anne's Gate, Westminster, London, S.W.1, with Mr. S. Langford as their London representative.

THE TREASURY has issued an order which came into operation on June 2, on the recommendation of the Import Duties Advisory Committee, reducing the duty on graphite electrodes of certain sizes specified in the schedule attached to the order.

MINING & INDUSTRIAL EQUIPMENT, LIMITED, 11, Southampton Row, London, W.C.1, report having received orders for a Hardinge mill and air plant, a Raymond pulveriser, four Hum-mer screens, a Ro-Tap testing sieve shaker, a three-roller Raymond mill, and a 3-ft. by 18-in. Hardinge mill.

The monthly record of the Sheffield Chamber of Commerce states that Sheffield is producing at least one-third more steel and is employing three thousand more workers than a year ago. Three big works have increased their output of heavy castings and more open-hearth steel is being produced and consumed.

The British Mannesmann Tube Company, Limited, Newport, have secured a substantial order for lap-welded steel pipes for the Rand Water Board in South Africa. The order comprises 40,000 ft. of 24-in. dia. by ¼-in. pipe, and 36,000 ft. of 16-in. dia. by ¼-in. pipe. Work on the contract is to start at once. The plates will be manufactured at the works of the British (Guest Keen Baldwins) Iron & Steel Company, Limited.

MESSRS. CRAVEN BROS. (MANCHESTER), LIMITED, advise us that they have completed arrangements under which Messrs. A. C. Wickman, Limited, Coventry, will be responsible for the sale in the whole of Great Britain, Northern Ireland and the Irish Free State, of the range of "Craven-Rigid" milling machines and a number of other special-duty high-production machines for the manufacture of motor-car components, etc. Messrs. A. C. Wickman, Limited, will be responsible for sales, and Craven Bros. will be responsible for design, manufacture and service.

Representatives of the steel industry have had an interview with Mr. Walter Runciman (President of the Board of Trade), when they expressed concern at the unsettlement of the steel trade in consequence of trade agreements with other countries. It was emphasised on behalf of the steel industry that it had been agreed to impose duties for a period that would enable permanent plans to be made. The deputation suggested that if there were to be any further changes there should at least be consultation between the Government and the interests concerned.

It is reported by the "Chinese Economic Bulletin" that the Chinese Ministry of Industry is negotiating with certain German interests for a loan of $6,000,000 for the exploitation of tungsten mines in the province of Kiangsi. A certain percentage of the profits will be paid to the Government as royalty, and the tungsten will be sold at market price, subject to approval by the Government. It is understood that after the agreement is signed, the Ministry and the German interests concerned will each appoint an expert to prospect the field to be developed.

STERLING FOUNDRY SPECIALTIES, LIMITED, Bedford, have secured the contract for the supply of the whole of the moulding-box equipment for the Britannia Iron & Steel Works, Limited, of Bedford. The order is for several thousands of boxes of special design. Another order just received by the Sterling Company is from the Stanton Ironworks Company, Limited, for the necessary moulding boxes for the production of C.I. road plates. We understand these will be used in the first instance for making the C.I. setts for the Mersey Tunnel, the contract for which was recently awarded to the Stanton Ironworks Company.

The Royal Mail Lines, Limited, have decided to re-condition and speed up their passenger liners "Asturias" and "Alcantara." The contract for the work has been secured by their builders, Messrs. Harland & Wolff, Limited, of Belfast. The power of each vessel is to be increased considerably, and the lines of the hulls will be modified to suit the higher speed. To give the necessary higher revolutions to enable existing shafting, etc., to be used and avoid other costly alterations, the owners state that the best solution of the problem has been found in the adoption of geared-turbine machinery, taking steam from high-pressure water-tube boilers.

Mr. W. A. Benton was elected President at the annual meeting of the Birmingham Metallurgical Society, held on May 30. The following were elected Vice-Presidents:—Messrs. H. Davies (senior), J. Fallon, N. P. Allen and E. A. Bolton; honorary treasurer, Mr. A. C. Craig; five members of the council, Messrs. H. J. Miller, C. H. H. Franklin, T. W. Ellett, P. A. Tucker and E. Pagett. It was stated in the annual report that the influx of new members had been maintained. Arrangements had been made to hold meetings at the James Watt Memorial Institute, Great Charles Street, Birmingham, where accommodation had been reserved for next session.

RESULTING FROM THE DEATH of Mr. Sanderson, who was long associated with Messrs. Sidney Flavel & Company, Limited, stove makers, Leamington, as reported on this page last week, we learn that the following appointments have been made:—Additional directors, Miss I. Lane and Mr. S. W. B. Flavel, B.Sc.; Mr. G. Westley is to be secretary and accountant and Mr. Burton-Smith is to be assistant secretary and cashier. Miss I. Lane has been associated with the company for fourteen years, and has been private secretary and chief of office administration. Mr. S. W. B. Flavel is the sixth generation of this old private family business, his uncle, Mr. Percival Flavel, J.P., being the present proprietor.

THE NEW BRIDGE over the Nile in Cairo known as the Khedive Ismail Bridge, which was opened by King Fuad I of Egypt on June 6, replaces the old Kasr-el-Nil Bridge which was completed in 1871, and which, owing to the increased volume of traffic and heavier loading due to motor traffic, was considered inadequate for present requirements. The new bridge is 1,260 ft. long and crosses the river in eight spans. It is 66 ft. in width, and an electrically-operated opening span is provided for the accommodation of river traffic, giving two clear passages each of 66 ft. The designs were prepared by Dorman, Long & Company, Limited, as engineers, in conjunction with Sir John Burnet & Partners as architects, and the structure presents a handsome appearance which is in keeping with its situation in one of the most picturesque parts of Cairo.

New Companies.

Wembley Aluminium, Limited, Wembley Hill Estate, Wembley.—Capital £5,000 in £1 shares. Directors: M. O. Court and Mrs. D. Wilson.

West Coast Hematite Ingot Moulds, Limited, Walney Road, Barrow-in-Furness.—Capital £100. Manufacturers of ingot and other moulds, dies, etc.

W. J. Harmer, Limited, 19, Mulkern Road, Upper Holloway, London, N.—Ironfounders, etc. Capital £2,500.

Durable Metals, Limited, Bush House, Aldwych, London, W.C.2.—Capital £1,000 in £1 shares. Directors: A. C. Glinister, Mrs. J. Glinister, H. T. Davies and Mrs. N. M. Davies.

Portobello Steelworks, Limited, Portobello Works, Congress Street, Sheffield.—Steel manufacturers and refiners, etc. Capital £1,500. Directors: A. Lee and F. M. Clements.

Millspaugh, Limited.—General engineers, manufacturers of forgings, castings, etc. Capital £1,000. Subscriber: L. F. Crane, Bush House, London, W.C.2.

Alcastings, Limited, 9 and 10, Kendrick Place, London, S.W.7.—Founders, manufacturers and suppliers of aluminium castings, foil, etc. Capital £1,000. Directors: E. T. Clisby, C. H. Ellis and H. J. T. Clements.

Personal.

MAJOR CHARLES WILLIAMS, Chief Inspecting Engineer for the Crown Agents for the Colonies, has become President of the Institution of Locomotive Engineers.

MR. R. H STEPHENSON, director and general manager of Messrs. Smith's Dock Company, Limited, North Shields, has been appointed a magistrate for Tynemouth.

MR. R. B. SUMMERSON, chairman and joint managing director of Messrs. Thomas Summerson & Sons, Limited, Darlington, railway-plant manufacturers, has been appointed a magistrate for the County of Durham. Mr. Summerson has been a member of the Darlington Rural Council since 1919.

Wills.

HADLEY, R. D., of Wolverhampton, iron-founder £23,784

GIBBONS, FREDERICK, of Finchley, metal merchant £16,384

Company Reports.

Turner & Newall, Limited.—Interim dividend on the ordinary stock of 1¼ per cent.

Crompton Parkinson, Limited.—Interim dividend on the ordinary and "A" ordinary shares of 6 per cent.

Crittall Manufacturing Company, Limited.—Payment of the dividend on the 7 per cent. cumulative preference shares due on June 1 is deferred.

Stanton Ironworks Company, Limited.—Final dividend on the ordinary shares of 6 per cent., making 10 per cent., less tax, for the year to March 31, 1933.

Stewarts and Lloyds of South Africa, Limited.—Dividend at the rate of 6 per cent. per annum on the first cumulative preference shares for the half-year to June 30, 1933.

Anderston Foundry Company, Limited.—Loss for year to March 31, £3,765; brought in, £1,459; transferred from reserve, £7,984; dividend of 4 per cent.; carried forward, £2,078.

Allied Ironfounders, Limited.—The directors recommend payment of the dividend on the 7 per cent. cumulative preference shares for the year to March 31, 1933, but do not propose to make any distribution on the ordinary shares

Guest, Keen & Nettlefolds, Limited.—Net credit balance, after charging debenture interest and providing £32,704 against profits for redemption of debenture stock, £133,665; brought in, £458,058; available, £591,723; dividend of 5 per cent. on the first preference shares, tax free, £91,000; carried forward, £500,723.

Contracts Open.

Langho, June 12.—12 iron fire-escape staircases, for Brockhall Institution, Langho, near Blackburn.

London, S.W., June 12.—Steel presses, for the Commissioners of His Majesty's Works. The Controller of Supplies, H.M. Office of Works, etc., King Charles Street, Westminster, London, S.W.1.

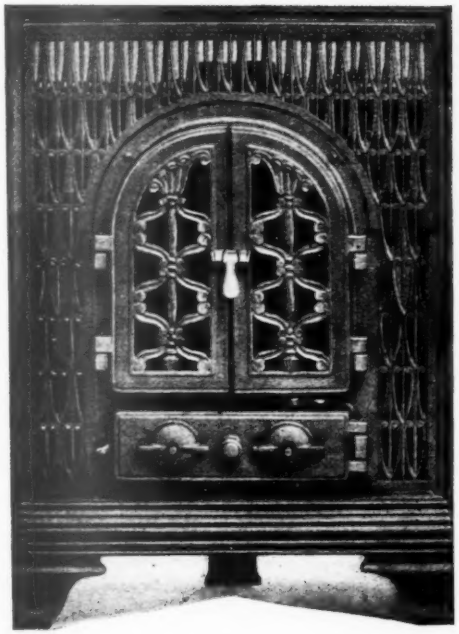
Maldon, June 20.—Supply and delivery of 250 yds. of 8-in. and 3,064 yds. of 6-in. cast-iron socket and spigot water pipes, with special castings, for the Town Council. Messrs. Rofe & Raffety, civil engineers, 208, Abbey House, Victoria Street, Westminster, S.W.1. (Fee £2 2s., returnable.)

Obituary.

MR. JOSEPH ELLERSHAW PEPPER, who died recently at Romsey, Hants, in his 89th year, was managing partner of Messrs. Taylor Bros. & Company, Limited, of Trafford Park, when the latter occupied the Clarence Iron and Steel Works, Hunslet.

MR. WILLIAM GIBBINS, for many years chairman of the Birmingham Battery & Metal Company, Limited, died at his residence, Hewletts, Cheltenham, in his 93rd year. Mr. Gibbins began work in the Battery Company's office at the age of 16, and became manager eight years later. He held this position, and subsequently that of chairman, until his retirement in 1925. Mr. Gibbins's business life was mainly concerned with Birmingham's non-ferrous metal trade. In this he held various responsible posts, for he was President of the Birmingham Exchange from 1904 to 1907, while for a long period he served the Brass and Copper Tube Association, first as honorary secretary and later as assessor.

XUM



For
Stoveplate
&
Enamelware
(especially vitreous)

FRODAIR
PIG IRON

Best
after
test

50 YEARS

FRODAIR IRON & STEEL Co., Ltd., FENCHURCH HOUSE, LONDON.

Raw Material Markets.

The iron and steel markets are now making a return to normal activities, following the Whitsuntide break. Home and overseas requirements have recently been at a fairly good level, and it is hoped that this standard will be maintained over the summer months. Little foreign material is now being imported, and home manufacturers have benefited correspondingly. It is to be hoped that the international financial conference being held in London this month will reach a satisfactory conclusion, as a large volume of stocking orders is being held up pending a clearer general outlook.

Pig-Iron.

MIDDLESBROUGH.—The local ironmasters are now stated to be better situated for work than they have been for several years past. A steady demand is being experienced, stocks are of manageable proportions, and new business is being done at the enhanced rates recently put into force. The export section remains disappointing, however; it is exceedingly difficult to attract attention, in spite of the very low prices quoted. In the home markets the fixed zone price system is working tolerably smoothly, though resentment is still expressed in some quarters at the preferential rates quoted to Scottish consumers, who can buy No. 3 Cleveland G.M.B. for 62s. 9d. per ton delivered Glasgow, which is only 3d. per ton more than the quoted price delivered Middlesbrough, and compares with the minimum of 64s. 6d. per ton delivered North-East Coast. Shipments of iron and steel from the Tees during May totalled 43,329 tons, compared with 33,367 tons in the previous month. This is the highest total since April, 1932. Pig-iron clearances showed a slight decline, which was offset by an improvement in finished iron and steel despatches.

East Coast hematite quotations remain at 59s. for mixed numbers and 59s. 6d. for No. 1 quality. There are six furnaces in blast on this grade of iron, the current demand being very nearly up to the output. Were it not for the existence of large stocks of unsold material, prices would almost certainly rise from their present uneconomic level. The possibility of a concerted move being made by the producers in this direction cannot be overlooked.

LANCASHIRE.—The pig-iron market in this area keeps a fairly steady position. Quotations show little alteration. For delivery to users in the Manchester zone, Midland brands of No. 3 foundry iron —Staffordshire and Derbyshire—are quoted on the basis of 67s. per ton, with North-East Coast iron at around the same figure, Northamptonshire at 65s. 6d., and Derbyshire forge at 62s. Offers of Scottish foundry are being made locally at down to about 80s. per ton, including delivery Manchester or equal, with East Coast hematite obtainable at around 75s. 6d. and West Coast hematite at 80s. 6d.

MIDLANDS.—The heavy engineering trades in this district remain badly situated for work, but the light-castings foundries are now busier than they have been for some months past. The Midland zone prices are 62s. 6d. for Northants No. 3 and 66s. for North Staffordshire, Derbyshire and Lincolnshire No. 3, which include delivery to Birmingham and Black Country stations. Cleveland iron is available at the same price as Derbyshire No. 3, and small quantities are still coming into this area. Forge iron for foundry work is 4s. below No. 3 foundry. This area continues to be a moderately good market for special foundry irons, the prices varying considerably, according to analysis. A low-phosphorus pig-iron is available at from 80s. to 90s. per ton, with medium-phosphorus iron from 70s. to 80s. per ton. No. 3 Scottish iron is at 83s. 6d. to 85s.

SCOTLAND.—Employment in the foundry industry is irregular, and the demand for pig-iron remains limited. A furnace was changed over last week from hematite to basic production, and there are now four furnaces on foundry iron, one on hematite and two on basic. There is no change in the price of foundry iron, which remains on the basis of 65s. f.o.t. furnaces for No. 3, with an extra 2s. 6d. for No. 1. No. 3 Middlesbrough is at 59s. 9d. at Falkirk and 62s. 9d. at Glasgow. Hematite prices are unaltered, as follow:—Mixed numbers, Scottish hematite, 66s.; ordinary mixed numbers, West Coast hematite, 68s. 6d. Scottish, Lincolnshire and Indian basic are all 57s. 6d., delivered steelworks.

Coke.

The call for foundry coke remains moderate, at unaltered prices. Best Durham coke is offered at 36s. 6d. to 38s. and Welsh coke at 30s. to 45s. A small amount of Scottish coke is entering the Midlands at about 40s. per ton. The above prices are all delivered in the Birmingham district.

Steel.

Although new business is still on a limited basis, the consumption of steel in this country remains at a fairly steady level. Makers of semi-finished material are benefiting from the virtual exclusion of the Continental product from the British market, but they are still far from fully employed. The position in the finished-steel market shows little change. Slightly better employment is reported in the heavy-steel industry. The absence of foreign competition is strengthening the small-steel-bar market.

Scrap.

Many scrap-iron consumers in the Cleveland district have now covered their requirements, and the local demand has fallen away. Ordinary heavy is quoted at 37s. 6d. and machinery quality at 40s. In the Midlands heavy machinery metal is at 45s. to 47s. 6d., pipe and plate scrap is at 42s. 6d. and clean light cast iron at 38s. 6d., all delivered. The demand in Scotland fails to show improvement, ordinary cast iron being at 44s. and light metal at 37s. 6d. per ton.

Metals.

Copper.—Although at times irregular, the copper market continues to display a firm tone, and quotations displayed a further rise on the reopening after the holiday. A fair trade is being done with users on this side, although the advance is mainly due to the increased consumptive buying which has taken place recently in the United States, where there is an improved industrial outlook. Profit-taking occurs from time to time on the London market, but seems to afford little check to the general course of the market.

The week's prices have been as follow:—

Cash.—Thursday, £38 2s. 6d. to £38 5s.; Friday, £38 1s. 3d. to £38 2s. 6d.; Tuesday, £38 10s. to £38 11s. 3d.; Wednesday, £37 11s. 3d. to £37 12s. 6d.

Three Months.—Thursday, £38 6s. 3d. to £38 7s. 6d.; Friday, £38 6s. 3d. to £38 7s. 6d.; Tuesday, £38 15s. to £38 16s. 3d.; Wednesday, £37 16s. 3d. to £37 17s. 6d.

Tin.—The upward sweep of quotations continues unchecked. Tuesday's market showing a further rise of over £5 per ton, in spite of the usual post-holiday hesitation. Messrs. Rudolf Wolff & Company state that a feature has been the comparative scarcity of metal for cash and near delivery, in consequence of which at times near dates commanded a small premium. In spite of the sharp advance and the relatively high price at which this metal is now ruling, the firm tone of the market is still well maintained, and reactions, as and when they have occurred, have been of short duration. Demand on the part of consumers is well maintained in this country, where fairly active conditions continue in the South Wales tinplate trade, as also on the Continent, whilst in America, where the improvement in the tinplate and motor industries has continued, a satisfactory demand has been reported. The outlook of this metal is generally well regarded in the belief that the statistical position in the present circumstances will continue to develop favourably, as it seems reasonable to assume some further expansion in consumption, and, furthermore, it is expected that stocks controlled by the Pool will only be disposed of as and when the trade of the world is ready to absorb them, and that such quantities would only be released as would not occasion any undue pressure on the market.

Daily quotations:—

Cash.—Thursday, £209 to £209 5s.; Friday, £209 17s. 6d. to £210; Tuesday, £215 7s. 6d. to £215 10s.; Wednesday, £215 10s. to £215 15s.

Three Months.—Thursday, £208 15s. to £209; Friday, £209 15s. to £210; Tuesday, £215 2s. 6d. to £215 5s.; Wednesday, £215 12s. 6d. to £215 15s.

Spelter.—The spelter market has shown a very firm tone within the last week. Although the position has been somewhat obscured by the amount of speculative activity, there seems to have been a fair amount of buying by the manufacturers. Owing to the continued improvement in the statistical position, the outlook for this metal is reckoned to be very favourable.

Price fluctuations:—

Ordinary.—Thursday, £16 10s.; Friday, £16 10s.; Tuesday, £16 12s. 6d.; Wednesday, £16 11s. 3d.

Lead.—Active dealing has been seen on this market recently, and the demand from actual consumers has been quite satisfactory. The demand for manufactured lead products has shown a very promising expansion during the last month or so.

Daily market prices:—

Soft Foreign (Prompt).—Thursday, £13 6s. 3d.; Friday, £13 5s.; Tuesday, £13 12s. 6d.; Wednesday, £13 7s. 6d.

Patent Specifications Accepted.

The following list of Patent Specifications accepted has been taken from the "Illustrated Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The last numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken

22,337. Folliet, A., and Sainderichin, N. Production of spongy iron 390,049.

24,971. Peters & Company, Limited, G. D. (Wilson Welder & Metals Company, Inc.). Arc-welding apparatus. 390,060.

28,646. Lamberts, E. Method of, and apparatus for, producing hollow bodies by centrifugal casting. 390,086.

25,807. Kistinger, E. Method and apparatus for the production of hollow metal castings. 389,021.

27,878. Vereinigte Stahlwerke Akt.-Ges. Process for treating iron or steel or their alloys for use for apparatus exposed to the action of hydrogen or gases containing same at elevated temperature and pressure. 389,887.

27,016. Garweg, A. Hardening medium and case-hardening of tools of iron or steel. 390,162.

27,376. Baker, C. J., and Skaredoff, N. E. Open-hearth furnaces. 390,207.

31,731. Soc. Oxythermique. Operation of blast furnaces for the production of iron or iron and cement. 390,246.

33,936. Vereinigte Stahlwerke Akt.-Ges. Steel suitable for objects subjected to heavy wear. 390,255.

34,021. Quasi-Arc Company, Limited, and Strohmenger, A. P. Electrodes or welding rods for use in electric-arc welding. 390,256.

16,876. Aichelin, J. (firm of). Process and apparatus for case-hardening iron. 390,357.

17,053. Nier, B. Tin plating. 390,360.

18,598. Potts, H. E. (Electro Metallurgical Company). Production of metal ingots. 390,372.

24,076. Kilburn, B. E. D. (Norske Aktieselskab for Elektrokemisk Industri). Apparatus for conveying molten slag. 390,407.

33,460. Eisenwerk Nürnberg Akt.-Ges. vorm. J. Tafel & Company. Manufacture of wrought iron. 390,460.

27,836. Electro Metallurgical Company. Production of metal castings. 390,533.

29,500. Busse, O. Extrusion of metal blanks, such as cylinders. 390,552.

Engineering firms in Leeds have recently received some substantial orders, which have meant a considerable reduction in unemployment figures. The Hunslet Engine Company, Limited, have received an order for six engines to be shipped to China, four Diesel locomotives for the L.M.S. Railway, and locomotives for India, Africa, Burma, and Newcastle. More men are now working than for some considerable time past. Messrs. Hudswell, Clarke & Company, Limited, have received orders from the L.M.S. and the War Office, while Messrs. Clayton, Son & Company are stated to have two-thirds of their normal employees now working. During the past month more orders have been received by Messrs. Henry Berry & Company, Limited, hydraulic engineers, than in any month since 1931.

Obtain Your Sand Blast Replacements

FROM

THE FIRM

Who Specialise in the Supply of every Type of Sand Blasting Equipment, the Firm who Invented and first Developed the Process.

If they don't know anything about it—Who Does?

Chilled Iron Shot—Crushed or round. Rubber Gloves. Rubber Blast Hose. Nozzles. Equipment for Operators. Exhaust Fans. Flint and Sand. Etc., Etc.

— PROMPT DESPATCH —

WE ARE ALSO MAKERS OF AIR COMPRESSORS & DUST ARRESTERS.

TILGHMAN'S

Telegrams: "Tilghman's Altrincham."

PATENT SAND BLAST Co. Ltd.

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88/121230. H.D

WARNER

.... universally recognised as the leading brand of Cylinder Pig Iron

CBR

The way to BETTER castings

WARNER & CO. LTD. CARGO FLEET MIDDLESBROUGH

WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	37 11 3
Three months	37 16 3
Electrolytic	42 10 0
Tough	39 10 0
Best selected	40 0 0
Sheets	68 0 0
India	51 0 0
Wire bars	43 0 0
Do., July	43 2 6
Do., August	43 5 0
Ingot bars	43 0 0
H.C. wire rods	45 5 0
Off. av. cash, May	34 2 1 2/5/6
Do., 3 mths., May	34 6 2 4/5
Do., Sttlmnt., May	34 2 2 2/5
Do., Electro, May	38 11 4 3/5
Do., B.S., May	37 2 6
Do., wire bars, May	38 19 5 1/5
Solid drawn tubes	10½d.
Brazed tubes	10½d.
Wire	7d.

BRASS.

Solid drawn tubes	9½d.
Brazed tubes	11½d.
Rods, drawn	8½d.
Rods, extd. or rlld.	4½d.
Sheets to 10 w.g.	8½d.
Wire	7½d.
Rolled metal	7½d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN.

	£ s. d.
Standard cash	215 10 0
Three months	215 12 6
English	216 15 0
Bars	218 5 0
Straits	232 17 6
Australian (nom.)	229 7 6
Eastern	226 10 0
Banca (nom.)	231 7 6
Off. av. cash, May	186 5 10 10/23
Do., 3 mths., May	186 13 7 3/23
Do., Sttlmt., May	186 6 8 21/23

SPELTER.

	£ s. d.
Ordinary	16 11 3
Remelted	16 0 0
Hard	14 10 0
Electro 99.9	18 17 6
English	17 7 6
India	15 5 0
Zinc dust	19 0 0
Zinc ashes	2 7 6
Off. aver., May	15 11 7 1/16
Aver. spot, May	15 10 1 7/23

LEAD.

	£ s. d.
Soft foreign ppt.	13 7 6
Empire	13 12 6
English	14 15 0
Off. average, May	12 4 8 3/23
Average spot, May	12 1 10 15/23

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	25 0 0
Do., V.M. ex-whse.	24 0 0
Rods	28 0 0
Boiler plates	—
Battery plates	—

ANTIMONY.

	£ s. d.
English	35 0 0 to 40 0 0
Chinese	28 0 0
Crude	—

QUICKSILVER.

	£ s. d.
Quicksilver	8 17 6 to 9 10 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro silicon—	
25%	7 15 0
45/50%	13 17 6
75%	19 12 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	6/3 per lb. of Mo.
Ferro-titanium—	
23/25% carbon-free	10d. lb.
Ferro-phosphorus, 20/25%	£17 17 6
Ferro-tungsten—	
80/85%	1/6 lb.
Tungsten metal powder—	
98/99%	1/9 lb.
Ferro-chrome—	
2/4% car.	28 5 0
4/6% car.	21 15 0
6/8% car.	20 15 0
8/10% car.	20 0 0
Ferro-chrome—	
Max. 2% car.	32 10 0
Max. 1% car.	35 5 0
Max. 0.70% car.	39 2 6
70% carbon-free	11d.
Nickel—99.5/100%	£225 to £230
"F" nickel shot	£202 10 0
Ferro-cobalt	5/9 lb.
Aluminium 98/99%	£100 0 0
Metallic chromium—	
96/98%	2/8 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/4 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 1/16 in.	1/– lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/– lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

South Wales—	£ s. d.	£ s. d.
Heavy steel	2 3 0	to 2 4 0
Bundled steel and shrngs.	1 17 6	to 2 4 0
Mixed iron and steel		2 0 0
Heavy cast iron		2 2 6
Good machinery	2 8 0	to 2 10 0
Cleveland—		
Heavy steel		1 17 6
Steel turnings		1 11 6
Cast-iron borings		1 2 0
Heavy forge		2 10 0
W.I. piling scrap		2 0 0
Cast-iron scrap	1 17 6	to 2 0 0
Midlands—		
Light cast-iron scrap		1 18 6
Heavy wrought iron		2 5 0
Steel turnings, f.o.r.	1 4 6	to 1 5 6
Scotland—		
Heavy steel	1 17 6	to 1 18 9
Ordinary cast iron		2 4 0
Engineers' turnings	1	1 11 6
Cast-iron borings		1 12 6
Wrought-iron piling		2 1 3
Heavy machinery	2 8 6	to 2 10 0

London—Merchants' buying prices, delivered yard.

	£ s. d.
Copper (clean)	28 0 0
Brass	19 0 0
Lead (less usual draft)	12 0 0
Tea lead	10 0 0
Zinc	10 0 0
New aluminium cuttings	74 0 0
Braziery copper	24 0 0
Gunmetal	22 0 0
Hollow pewter	115 0 0
Shaped black pewter	85 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	65/–
Foundry No. 3	62/6
,, at Falkirk	59/9
,, at Glasgow	62/9
Foundry No. 4	61/6
Forge No. 4	61/6
Hematite No. 1, f.o.t.	59/6
Hematite M/Nos., f.o.t.	59/–
N.W. Coast—	
Hem. M/Nos. d/d Glas.	68/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/–
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	62/–
,, No. 3 fdry.	66/–
Northants forge	58/6
,, fdry. No. 3	62/6
,, fdry No. 1	65/6
Derbyshire forge	62/–
,, fdry. No. 3	66/–
,, fdry. No. 1	69/–
Scotland—	
Foundry No. 1	67/6
,, No. 3	65/–
Hem. M/Nos. d/d	66/–
Sheffield (d/d district)—	
Derby forge	59/6
,, fdry. No. 3	63/6
Lincs forge	59/6
,, fdry. No. 3	63/6
E.C. hematite	75/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	67/–
Staffs fdry. No. 3	67/–
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/–
Dalzell, No. 3 (special)	102/6 to 105/–
Glengarnock, No. 3	82/–
Clyde, No. 3	82/–
Monkland, No. 3	82/–
Summerlee, No. 3	82/–
Eglinton, No. 3	82/–
Gartsherrie, No. 3	82/–
Shotts, No. 3	82/–

FINISHED IRON AND STEEL.

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	9 0 0	to 9 15 0
Nut and bolt iron	6 15 0	to 7 10 0
Hoops	10 10 0	to 12 0 0
Marked bars (Staffs) f.o.t.	12 0 0	
Gas strip	10 10 0	to 12 0 0
Bolts and nuts, ¾ in. × 4 in.	12 17 6	
Steel—		
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.		8 5 0
Chequer plts.		10 7 6
Angles		8 7 6
Tees		9 7 6
Joists		8 15 0
Rounds and squares, 3 in. to 5½ in.		9 7 6
Rounds under 3 in. to ⅜ in. (Untested)	6 15 0	& up.
Flats—8 in. wide and over		8 12 6
,, under 8 in. and over 5 in.		8 17 6
Rails, heavy	8 5 0	to 8 10 0
Fishplates		12 0 0
Hoops (Staffs)	9 10 0	& up.
Black sheets, 24g. (10-t. lots)		9 15 0
Galv. cor. shts. ,,		12 0 0
Galv. flat shts. ,,		12 10 0
Galv. fencing wire, 8g. plain		14 0 0
Billets, soft	5 0 0	to 5 12 6
Billets, hard	6 12 6	to 7 2 6
Sheet bars	4 15 0	to 5 2 6
Tin bars		4 15 0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	11d.
Sheet to 10 w.g.	12d.
Wire	12½d.
Rods	11d.
Tubes	15½d.
Castings	13d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	16.34
No. 2 foundry, Valley	14.50
No. 2 foundry, Birm.	12.00
Basic	15.89
Bessemer	16.89
Malleable	16.39
Grey forge	16.89
Ferro-mang. 80%, seaboard	68.00
O.-h. rails, h'y, at mill	40.00
Billets	26.00
Sheet bars	26.00
Wire rods	35.00
	Cents.
Iron bars, Phila.	1.86
Steel bars	1.60
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.60
Steel hoops	1.55
Sheets, black, No. 24	2.10
Sheets, galv., No. 24	2.70
Wire nails	1.85
Plain wire	2.10
Barbed wire, galv.	2.35
Tinplates, 100-lb. box	$4.25

COKE (at ovens).

Welsh foundry	20/– to 22/6
,, furnace	15/– to 16/–
Durham and Northumberland—	
,, foundry	21/– to 25/–
,, furnace	13/3
Midlands, foundry	—
,, furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	17/– to 17/3
,,	28×20 ,,	34/– to 34/6
,,	20×10 ,,	24/9
,,	18¾×14 ,,	18/–
C.W.	20×14 ,,	15/6 to 15/9
,,	28×20 ,,	32/6
,,	20×10 ,,	—
,,	18¾×14 ,,	—

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0	to £7 0 0
Bars-hammered, basis	£16 10 0	to £17 0 0
Bars and nail-rods, rolled, basis	£15 17 6	to £16 5 0
Blooms	£10 0 0	to £12 0 0
Keg steel	£32 0 0	to £33 0 0
Faggot steel	£18 0 0	to £23 0 0
Bars and rods dead soft, st'l	£10 0 0	to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
June	1 ..	38	2	6	dec.	2/6
,,	2 ..	38	1	3	,,	1/3
,,	6 ..	38	10	0	inc.	8/9
,,	7 ..	37	11	3	dec.	18/9

Standard Tin (cash).

		£	s.	d.		
June	1 ..	209	0	0	dec.	25/–
,,	2 ..	209	17	6	inc.	17/6
,,	6 ..	215	7	6	,,	110/–
,,	7 ..	215	10	0	,,	2/6

Spelter (ordinary).

		£	s.	d.		
June	1 ..	16	10	0	dec.	7/6
,,	2 ..	16	10	0	No change	
,,	6 ..	16	12	6	inc.	2/6
,,	7 ..	16	11	3	dec.	1/3

Zinc Sheets (English).

		£	s.	d.		
June	1 ..	25	0	0	inc.	10/–
,,	2 ..	25	0	0	No change	
,,	6 ..	25	0	0	,,	,,
,,	7 ..	25	0	0	,,	,,

Electrolytic Copper.

		£	s.	d.		
June	1 ..	43	0	0	dec.	5/–
,,	2 ..	43	0	0	No change	
,,	6 ..	43	5	0	inc.	5/–
,,	7 ..	42	10	0	dec.	15/–

Tin (English ingots).

		£	s.	d.		
June	1 ..	210	5	0	dec.	10/–
,,	2 ..	211	5	0	inc.	20/–
,,	6 ..	216	15	0	,,	110/–
,,	7 ..	216	15	0	No change	

Spelter (Electro, 99.9 per cent.).

		£	s.	d.		
June	1 ..	18	15	0	dec.	5/–
,,	2 ..	18	15	0	No change	
,,	6 ..	18	17	6	inc.	2/6
,,	7 ..	18	17	6	No change	

Lead (English).

		£	s.	d.		
June	1 ..	14	15	0	dec.	5/–
,,	2 ..	14	15	0	No change	
,,	6 ..	15	0	0	inc.	5/–
,,	7 ..	14	15	0	dec.	5/–

AVERAGE MONTHLY PRICES OF IRON HOOPS.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1897	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 8
1898	6 10 0	6 10 0	6 10	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	7 0 0	6 11 6	
1899	7 0 0	7 0 0	7 0 0	7 0 0	7 12 6	10 12 6	8 12 6	8 12 6	8 12 6	9 2 6	9 7 6	9 17 6	8 2 9
1900	9 17 6	10 7 6	10 7 6	10 7 0	10 12 6	7 12 6	10 12 6	10 12 6	10 12 6	9 17 6	9 2 6	9 2 6	10 3 8
1901	9 2 6	8 2 6	8 2 6	7 12 6	7 12 6	7 12 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 11 2
1902	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6
1903	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 0
1904	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6
1905	6 17 6	7 0 0	7 0 0	7 0 6	7 0 0	7 0 0	7 2 6	7 2 6	7 2 6	7 7 6	7 0 0	7 7 6	7 2 0½
1906	7 10 0	7 17 6	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	8 7 6	7 15 1½
1907	8 7 6	8 7 6	8 7 6	8 7 0	8 7 6	8 7 6	8 10 0	8 10 0	8 10 0	8 5 0	8 5 0	8 0 0	8 7 1
1908	8 0 0	7 10 0	7 10 0	7 10 6	7 10 0	7 10 0	7 10 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 6 8
1909	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0
1910	7 1 10½	7 6 3	7 7 6	7 7 0	7 7 6	7 7 6	7 7 6	7 7 6	7 7 6	7 6 3	7 5 0	7 5 0	7 6 5
1911	7 5 0	7 5 0	7 5 0	7 5 6	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 8 9	7 10 0	7 10 0	7 6 2½
1912	7 12 6	7 12 6	7 12 6	7 15 0	8 2 6	8 2 6	8 2 6	8 2 6	8 12 6	8 12 6	8 12 6	8 15 0	8 2 3½
1913	8 17 6	8 17 6	8 17 6	8 17 0	8 17 6	8 17 6	8 17 6	8 17 6	8 7 6	8 7 6	8 7 6	8 7 6	8 12 6
1914	7 17 6	7 17 6	7 17 6	7 13 9	7 12 6	7 12 6	7 12 6	9 2 6	9 2 6	9 2 6	9 2 6	9 2 6	8 6 4½
1915	9 3 6	9 18 1	10 7 6	10 16 6	10 17 6	13 2 6	13 2 6	13 2 6	13 7 6	14 2 6	15 2 6	15 18 6	12 10 1
1916	17 2 6	17 2 6	17 2 6	17 6 3	17 7 6	17 7 6	17 7 6	17 7 6	17 7 6	17 7 6	17 7 6	17 7 6	17 6 1
1917	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6
1918	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6
1919	17 2 6	17 2 6	17 2 6	17 2 6	24 6 3	24 6 3	24 6 3	25 9 0	26 7 6	26 7 6	26 7 6	26 17 4	22 14 9
1920	28 0 0	28 12 6	33 15 0	35 5 0	35 15 10	38 17 6	38 17 6	38 17 6	38 17 6	38 17 6	36 17 6	36 17 6	35 14 9
1921	29 1 3	23 5 0	21 12 6	20 0 0	20 0 0	20 0 0	17 5 0	15 0 0	14 4 0	13 15 0	13 10 0	12 18 0	17 5 10
1922	16 5 0	15 13 9	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	13 4 6½
1923	14 0 0	15 0 0	15 0 0	15 0 0	15 6 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	14 16 0	14 15 0	14 18 3½
1924	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 13 9	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 12 4½
1925	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0
1926	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0
1927	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	12 10 0	12 10 0	14 3 4
1928	12 10 0	12 7 6	12 0 0	11 13 6	11 15 0	11 12 6	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 14 10½
1929	11 10 0	11 10 0	11 10 0	11 10 0	11 9 0	11 5 0	11 5 0	11 5 0	11 5 0	11 2 0	11 0 0	11 0 0	11 5 11
1930	11 0 0	11 0 0	11 0 0	10 16 3	10 15 0	10 15 0	10 15 0	10 15 0	10 15 0	10 15 0	10 15 0	10 15 0	10 16 4½
1931	10 15 0	10 15 0	10 15 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 11 3
1932	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0
1933	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	—	—	—	—	—	—	—	—

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